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DEVELOPING A SUSTAINABLE ENERGY VISION FOR THE ENVIRONMENT AGENCY

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1 INTRODUCTION

1.1 The Aims of the Project

This project has aimed to take forward the Environment Agency's contribution to sustainable energy, and to develop the Agency's capacity to undertake a leadership role in sustainable energy. It has consisted of two main elements; firstly, researching and writing an holistic and robust vision of sustainable energy for the UK, and secondly, stimulating and provoking the organisation to consider the need for an Agency energy policy and the content of that sustainable energy policy. Both aspects of this project have represented substantial challenges, and taken as a whole the project has been quite ambitious – that of drafting a sustainable energy policy and then encouraging the Agency to officially adopt it.

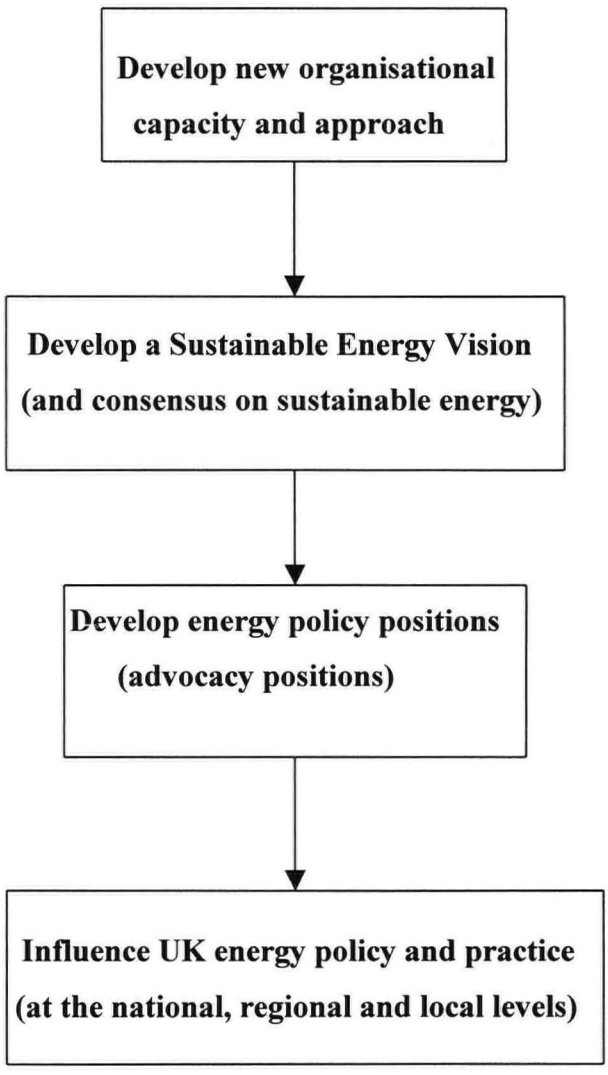
The project has been embedded within a substantial process of change and redirection within the organisation. My work has contributed to the Sustainable Development Unit's general programme of work, and a key component of the project has involved encouraging the Agency to embrace a high profile and, potentially risky, new approach to sustainable development. My project has promoted the message that the Environment Agency needs to engage in the politics of sustainable development if it wishes to be more influential in shaping key sustainability issues, such as energy, and that developing policy positions on sustainability issues is the first step in that process. Over the last year of my project, the Sustainable Development Unit has undertaken a specific policy advocacy initiative to encourage the organisation to adopt advocacy as a sustainable development tool, and to develop the organisation's capacity to develop and disseminate advocacy messages. Prior to this initiative, one way in which my work promoted this agenda was through producing internal discussion papers to advocate approaches and stimulate thinking. These discussion papers have been vital products of my research work, and the main ones are appended to this paper. There have been significant positive developments during the course of my work, and my project has played a role in contributing to this. The Agency is in the process of considering the energy vision I drafted and is putting the structures in place to develop energy positions. The organisation is now on the verge of adopting an energy vision and a set of robust policy advocacy positions on sustainable energy.

In my role as sustainable energy researcher I have sought to develop a robust understanding of sustainable energy, and paint a picture of a sustainable energy system. The Agency has needed to develop a shared understanding because there are many divergent views on the meaning of sustainable energy, and the best policies for the future. A particularly divisive issue is that of whether nuclear power is necessary for the delivery of a climate-friendly energy system. This issue was particularly stalling the internal sustainable energy debate, and therefore the development of an Agency sustainable energy position, and it was a key investigation within my energy research. Assessing the ability of renewable energy and improved energy productivity to meet our energy service needs, and to deliver the required reductions in carbon dioxide emissions for addressing climate change, has been a central project objective. This research has taught me a great deal and it has inspired me about the positive prospects for the future. The main products of this research have been the development of a Sustainable Energy Vision for the Environment Agency and an Environment Agency Renewable Energy Position Statement (which are appended to this paper). I believe that the sustainable energy vision has made a valuable contribution to the sustainable energy debate within the Agency, and within the UK energy policy community as a whole. Much of the argument and analytical material which underpins my understanding of sustainable energy is presented in the vision document (indeed, the energy vision is effectively a direct communication of my understanding of what constitutes sustainable energy, and the research I have based this upon) and therefore, to avoid repetition, I refer to this underpinning research only briefly in the following text.

This first chapter provides a brief introduction to the aims and context of this project. The second chapter then examines the role of the Environment Agency in delivering sustainable development and sustainable energy, and examines ways in which it may improve its contribution. It also introduces the arguments for why I undertook the project and the key messages that I have conveyed as a component of the project work. The third chapter outlines the complexities of the sustainable energy debate, the challenge involved in developing a position, and coming to an opinion on, sustainable energy and the approach I decided to adopt. The fourth chapter introduces my position and role within the organisation in the context of this project.

The fifth chapter outlines the literature review that I undertook for the project work, and the sixth my methodological approach. The seventh chapter presents my project activity in seeking to deliver my project objectives and influence Agency opinion, and it documents my developing understanding of sustainable energy. The eighth attempts to evaluate the impact of my project work and my success in delivering my original objectives. Finally, the appendices include some of the main products of the project. This includes the key output, which is a Sustainable Energy Vision for the Environment Agency, a Renewable Energy Policy Position for the Agency, an internal discussion paper on the need for an Agency energy position, and an internal discussion paper which looks at the key issues involved in an analysis of sustainable energy.

Developing the Environment Agency's Contribution to Sustainable Energy



1.2 The Challenge of Sustainable Energy

The use of fossil fuels in the provision of energy is a primary cause of many environmental problems facing the UK and the rest of the world. The combustion of fossil fuels is both the primary source of local air pollutants such as NO_x, SO_X and particulates, and also of the global atmosphere pollutant, CO_2. In addition, fossil fuels are a finite resource whose availability will decline over the coming century if current rates of consumption continue (and continue to increase). Approximately three-quarters of the UK's greenhouse gas emissions result from the combustion of fossil fuels for energy.[1] For the UK to reduce its greenhouse gas emissions to the levels recommended by the IPCC[2] will require a transition to a carbon-limited energy system during this century which will in turn require profound changes in the way we produce and consume energy. We should not underestimate the importance of undertaking this energy transition, nor the scale and profundity of the changes that will be needed. For these reasons, achieving sustainable energy will be one of the key challenges in the pursuit of a sustainable way of life. In its recent energy study[3], the Royal Commission on Environmental Pollution supports the IPCC's recommendations and endorses a long-term goal to reduce UK fossil fuel use by 60 – 80% over the course of this century. This is the urgent challenge that faces us.

This is only a brief overview of the unsustainability of our current energy system. However, the environmental problems associated with society's production and use of energy are extremely well documented and there is general consensus that fairly fundamental change is required in order to improve the sustainability of energy use. The work of the IPCC has achieved very high levels of agreement amongst the world's atmospheric scientists, and there is now a very broad and substantial consensus that fossil fuel combustion is driving global climate change. It is this mature and comprehensive body of work that underpins the rationale for my project research – which is, that we need to transform the way we produce and use energy. The focus of my project has not been that of further analysing the environmental

[1] (DoE, 1997) *Climate Change – The UK Programme*, HMSO, London

[2] The Intergovernmental Panel on Climate Change (IPCC) recommends a 60 – 80% reduction on 1990's level for greenhouse gas emissions from industrialised countries over the course of this century in order to ensure avoidance of potentially dangerous perturbation of the global atmosphere, (IPCC 1995) *The Science of Climate Change – Summary for Policy Makers*

[3] *Energy – The Changing Climate,* the twenty-second report of the Royal Commission on Environmental Pollution. June 2000

impacts of our current energy system, but to investigate and illuminate the best solutions for delivering sustainable energy. This has been the focus of my research and the issues upon which I have sought to influence the Environment Agency.

The Environment Agency's senior managers have for some time recognised the vital importance of delivering sustainable energy as a key component of sustainable development, and they wish the organisation to develop its contribution to catalysing change. However, the organisation has had no clear understanding of how to go about doing this or how to demonstrate leadership in sustainable energy - and doing so will involve moving beyond its regulatory duties into the political world of sustainable development.

1.3 Developing the Role of the Environment Agency

The Environment Agency is the main environmental regulation body for England and Wales, and is responsible for regulating pollution to land, air and water and for managing the water environment. Although a government body, the Agency has a certain degree of freedom from central government and is responsible for determining the best way to deliver its statutory duties. The Agency is in the process of change and is seeking to develop its identity and influence. The Agency has stated that it wants to take forward its contribution to sustainable development so that it acquires a leadership role in stimulating change for a sustainable society.

The Sustainable Development Unit within the Agency's Head Office leads the organisation's understanding of, and contribution to, sustainable development. Working within the Sustainable Development Unit, the objective of this project has been to develop the Agency's contribution to sustainable energy. This has required my involvement in, and shaping of, the change process within the organisation, and illuminating how the Agency can most effectively influence energy practices and policy in the UK. A key message of my research is that the Agency needs to develop a new approach and new capacity if it wishes to make an impact upon energy practices in the UK; as an essential first step it needs to develop opinion on what a sustainable energy system would look like, and help establish a long-term target for energy policy.

1.4 My Own Understanding of Sustainable Energy

I began the project with a personal understanding of sustainable energy which included increased energy efficiency and increased deployment of renewable energy. Indeed, this is the mainstream view of the environmental community, and that of the environmental pressure groups. The justification and arguments supporting this position are presented in the sustainable energy vision document found in appendix 1. In undertaking this research project I have been keen to test out this opinion, and also to further develop my understanding of the area and to develop a more complete mental picture of a sustainable energy future. Thus, this is the ideology and bias that I have brought to the project. A key component of the sustainable development process is that of thrashing out the differing opinions on the most sustainable options for the future. I believe that my understanding of both sustainable energy, and of the wider principles of sustainable development, has grown significantly during the duration of my work. I feel that I now have a fuller grasp of the concept of sustainable development as a guided process of economic and societal change, and I now put an increased emphasis on the role of market-led innovation as a key vehicle for driving the solutions for a sustainable society.

2 TAKING FORWARD THE ENVIRONMENT AGENCY'S CONTRIBUTION TO SUSTAINABLE ENERGY

2.1 The Purpose and Role of the Environment Agency

The Environment Agency is the principal environmental regulator for England and Wales, and is responsible for regulating pollution releases to land, air and water and for managing the water environment. It was formed in 1996 through the amalgamation of the National Rivers Authority, Her Majesty's Inspectorate of Pollution and a large number of waste regulation authorities across England and Wales. A principle reason for integrating these bodies was to bring these different aspects of environmental regulation under the control of one organisation so as to create a large, powerful and integrated environmental regulator which could undertake balanced protection of the environment as a whole. In carrying out the very large number of statutory duties with which it is tasked the Environment Agency's principal aim is to contribute to the Government's overall commitment to sustainable development. This commitment to sustainable development is specified in government guidance to the Environment Agency. In the years since its formation the Environment Agency has been wrestling with the challenge of how it can best implement its powers so as to most effectively ensure a balanced protection of the environment. It has also been considering its wider role in terms of contributing to sustainable development. As part of this process the Agency has produced an Environmental Vision[4] which outlines aspirational environmental outcomes for the future and the new ways of working that the Agency should adopt in order to improve its ability to contribute to the delivery of these outcomes. The Environmental Vision thereby provides the Environment Agency with an over-arching holistic approach to protecting and improving the environment, and for improving its contribution to sustainable development. The Vision is clear in outlining the Agency's intention to move beyond focusing narrowly on the delivery of its statutory duties to become a body with a wider outlook which aims to act as a force for sustainable development.

[4] An Environmental Vision – The Environment Agency's Contribution to Sustainable Development, January 2001

With specific regard to energy, the Agency regulates certain emissions from large fossil fuel powered electricity generating stations and the disposal of radioactive waste from nuclear power stations. It also regulates the activities of oil refineries. The Agency has also recently acquired the duty of considering the efficiency of energy use by all those industries that it regulates. There are also energy implications arising from the environmental standards that the Agency enforces on various industrial processes, for example, cleaning up certain pollutants is an energy intensive process. In addition to this the Agency is a substantial energy user itself. These duties alone provide good reason for the Agency to be interested in the sustainability implications of society's use of energy – and the ways in which it is produced, transported and consumed. In addition to this, the Environmental Vision highlights energy as a fundamental aspect within the achievement of sustainable development, and the desire of the organisation to play its role in delivering sustainable energy in the UK.

It is challenging for the Environment Agency, which is mainly a command and control regulator dealing with end-of-pipe pollution, to become a catalyst for societal and economic change. There is a significant difference between end-of-pipe regulation which contributes to environmental improvement, and acting as a leader for sustainability, which requires addressing the drivers and root causes of environmental degradation. My project has sought to contribute to the general process of change which is taking forward the Agency's contribution to sustainability leadership, specifically in the area of energy.

2.2 Conveying my Understanding of Sustainable Development to the Agency

The main question that I have grappled with over the course of my project is that of how the Agency can improve its contribution to sustainable energy. I have sought to shed light on how the Environment Agency can provide leadership in sustainable energy, and what this means exactly. What activities would the Agency need to undertake to demonstrate leadership? My understanding of demonstrating leadership in sustainable development (and the understanding that I brought to this project) is that of highlighting the best way forward and providing decisive vision about sustainability solutions. Leadership is needed most where there is the greatest confusion and uncertainty over the way forward. Delivering sustainable energy is

just such an issue of uncertainty and disagreement. In order to demonstrate leadership the Agency needs to take forward the long term solutions for sustainable energy and encourage Government to do the same. Government is currently failing to provide this leadership, and so if the Agency wishes to have an impact then it needs to develop its opinions on the best way forward. The following outlines my understanding of demonstrating leadership in sustainable development:

"My Understanding of Sustainable Development as a Political Process of Societal Change

Environmental problems continue to increase because our economic and social system is undermining the environment and the resources upon which it depends. Obviously, the regulatory duties that the Agency has inherited from its predecessor bodies cannot by themselves solve the environmental problems that the UK faces, only Government and society as a whole can do this. The roots of these problems lie deep within the workings of our current economic and social systems, and the concept of sustainable development has arisen as a response to this situation.

Brundtland's is the mostly widely used definition of sustainable development; "development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). However, this is a very broad, unspecific definition that leaves the main issues unresolved; namely, what are society's needs and how can we satisfy these without undermining our environment. There is no universally agreed understanding of how to deliver sustainable development, and different individuals have differing visions of what a sustainable world will look like. These are issues that need to be resolved as the sustainable development process takes place. Nevertheless, it is clear that sustainable development is about change – it is about changing our model of development – and it will be a learning process because society has yet to decide exactly what its needs are, and how to deliver its services sustainably.

At this stage we do not yet know all the details about how to improve the sustainability of all the activities in our economy and society. The process will require trial and error and will incorporate technological, institutional and cultural

change. As Burgess et al (1999)[5] puts it, "..sustainable development will remain a contested question that will continue to engage firmly with cultural and political issues in reaching judgements about the environment". For this reason sustainable development is (and will continue to be) an inherently political process. Sustainability issues go to the heart of all decision-making in central and local government and in business and will require debate and arguments as to the best solutions. Disagreements between environmental campaigning groups, business and government over what are the best sustainability solutions demonstrate that sustainable development is a political process that requires debate and deliberation. Sustainable energy is a characteristically political sustainability issue. There is no agreed definition of sustainable energy, and even amongst those with the same definition there is argument over how best to deliver it.

However, a key aspect of sustainable development is that of promoting sustainability thinking and the interests of the environment at all levels of decision making in the UK. This is recognised by Burgess et al (1999), "Fundamentally, sustainable development is about a change in values, and in particular the promotion of a set of values that raises the status of the environment when seeking to balance social, economic and environmental aspects of decision making". In many respects it is the vocal involvement of environmental bodies in the political and education process that raises the profile of sustainability concerns and influences the evolving values of society. This is particularly important because sustainable development will require changes (in industry and all other economic sectors) and any change needs to overcome inertia and vested interests."

This is my understanding of sustainable development as a change process, and it is with this message that I have sought to influence the Agency. A key aspect of my project has involved contributing to the Sustainable Development Unit's work of raising awareness and encouraging the Agency to recognise the strong political aspects accompanying sustainable development leadership.

[5] *An Analytical and Descriptive Model of Sustainable Development for the Environment Agency*, Environment and Society Research Unit, UCL, 1999

2.3 The Agency's Evolving Understanding of Leadership in Sustainable Development

As outlined above, because sustainable development is a process of societal change, it is an inherently political process. If an organisation is to show leadership in sustainable development then it needs to stimulate and lead (or influence) the process of change, overcome the barriers that are met on the way, and develop firm ideas about the best solutions. I believe that in order to contribute fully (or demonstrate leadership) to sustainable development the Agency will need to become fully involved in the decision-making processes occurring across government and society at the national, regional and local level.

In concentrating on delivering its statutory duties, the Agency has in the past had a fairly marginal involvement in the wider debate on key sustainability issues. Many sections of the organisation are still very hesitant about the Agency becoming more active in these areas, arguing that because the Agency is a government body it should follow government policy rather than challenge it. They argue that the Environment Agency has not been designed and structured so as to develop opinions and policy on complex environmental issues, and they question whether it has the mandate to do so. To date, the natural reaction of the organisation has been to shy away from controversial issues and high-level decision-making. The organisation has tended to prefer adopting well accepted mainstream environmental messages rather than develop its own opinions on complex, controversial issues, such as nuclear power, genetic modification or topical environmental issues in the press. And yet it is these issues on which society most desperately needs leadership. The Agency has, therefore, been reducing its scope for sustainable development leadership by avoiding involvement in the more unresolved, political sustainability issues. Thus, over the course of my project work, the Agency has been struggling to understand how it can play a more active role in this process of societal change and the challenge of demonstrating leadership.

Nevertheless, through launching its "Environmental Vision" in January 2001 the Agency has set rolling an internal process of change. The Environmental Vision outlines the organisation's intentions to adopt a more influencing and educational role to augment its regulatory duties and work towards joined up solutions for

sustainable development. The Chairman and Chief-Executive are also keen that the Agency should develop opinions on key issues on which its regulatory duties impact.

One of the main objectives of my project has been to contribute to this process of change and to promote a key message of the Sustainable Development Unit's that the Agency needs to become more active in the national, regional and local sustainability debates. My understanding and opinion regarding the actions that the Agency should undertake have developed over the two years of the project activity. Although there has been a great deal of progress over the past two years, and the process of change is now gathering more and more momentum, there is still a significant element within the organisation that has yet to come to accept the view that sustainable development is an inherently political process.

2.4 Developing an Energy Vision as a Means of Taking Forward the Agency's Understanding of, and Contribution to, Sustainable Energy

The energy debate is a very complex one because of the huge number of variables that need to be taken into account, and the need to consider how these variables might change in the future. In my project proposal I outlined my belief that the best way for the Agency to manage some of these complexities, and develop a consensus on sustainable energy, would be through the development and adoption of an aspirational long-term energy vision. I argued that an energy vision would enable the Agency to look beyond the short-term problems towards long-term opportunities, and thereby guide the Environment Agency in determining its own priorities for sustainable energy. The energy vision that I have researched and written for the Environment Agency, as a key component of this project, is successful in doing just that, and has fuelled the sustainable energy debate both internally and externally. The Agency has determined to use the energy vision as a foundation for an official Agency document comprising an energy vision and the policy recommendations for delivering it. In the meantime, the Agency will also use the energy vision as the basis for its interactions with the external energy policy community, and as a basis for discussions on sustainable energy and developing energy policy positions.

One of the main barriers to the development of a sustainable energy system in the UK is the lack of a long-term goal and consensus over what constitutes sustainable

energy. The sustainable energy vision helps to dismantle this barrier by articulating the need for a clearer direction for energy policy, and helping develop consensus over what the future energy goal should be. Using the energy vision as its guide, the Agency could also help to stimulate the regulatory, market and institutional changes needed to deliver sustainable energy and thereby become a more active participant in the energy debate.

2.5 A Climate of Change – The New Chairman and Chief-Executive, and the Environmental Vision

Over the course of my project work there have been many changes within the Agency which have stimulated the process of evolution towards a more political body with a more holistic approach to sustainable development (in terms of entering the sustainability debate) – changes that I have been a part of, and that have further enabled my work. Firstly, during the early stages of my project the Agency acquired a new chairman, and, at the end of 2000, it appointed a new chief-executive. This change in senior staff has had a significant impact upon the direction and character of the organisation. The arrival of the new Chairman, Sir John Harman, has provided powerful support for the Sustainable Development Unit in stimulating the Environment Agency to act as a more proactive force for sustainable development, and for sustainable energy in particular. The Sustainable Development Unit has always faced a very challenging situation because it is a small unit within a very large organisation. However, the new Chairman has provided a lot of support for the messages that the Unit has been promoting. Sir John is developing his role as a figurehead for the Environment Agency, and its role as a force for sustainable development. He has been vitally important to the process of change in the organisation and for taking forward the Agency's approach to complex sustainability issues. The new Chief-Executive, Barbara Young, has arrived towards the end of my project work. She is also a very high profile individual, well known in the environmental field, who wishes to take forward the Agency's contribution to sustainable development in the UK. She would like to raise the Agency's profile and increase its impact upon the sustainable development process in the UK.

These changes in senior management, coupled with the publication of the Environment Agency's Environmental Vision, have set the climate for substantially

changing the Agency's approach to environmental protection, and sustainable development, in the immediate and longer-term future. Thus, my project work has been a part of this wider organisational change process, and I have witnessed at first hand the challenges involved in stimulating organisational change and in developing the solutions for delivering the aspirations the Agency has sent itself in its Environmental Vision. These issues are considered in more depth in my reflections on project activity below.

2.6 A Risk Averse Culture

In general there is a risk averse culture within the Environment Agency and a general avoidance of controversy. The delivery of sustainable development is fundamentally different to that of traditional environmental protection which has in the main been carried out through command and control regulation.[6] Traditional regulation can only go so far as a means of mitigating environmental problems and it is often difficult to get to the root cause of environmental problems through the use of regulation.[7] As the drivers of these problems are societal and economic, the policy solutions need to influence the market-place and deliver institutions that can enable societal change. The Agency's expertise does not lie in these areas and so the organisation is unlikely to understand them fully. It is likely to think in terms of environmental regulation as the means for delivering sustainable development rather than the use of more dynamic market instruments, and the need to instigate more radical changes in the way society delivers its goods and services.

Much of the environmental protection work of the Agency deals with end-of-pipe control. Taking sustainable energy as an example, it is clear that the regulatory work of the Agency is very much concerned with regulating the "old" way of doing things. The Agency regulates the emissions coming out of the stacks of the large power stations. However, it is generally agreed that the future of sustainable energy provision (in terms of fossil fuel use) lies in much smaller combined heat and power plants. Thus, the most important drivers for sustainable electricity are those which encourage and deliver a decentralised electricity system and yet the official duties of the Environment Agency have nothing to do with the delivery of a decentralised

[6] See Jackson, T. (1996) *Material Concerns – Pollution, Profit and Quality of Life,* Earthscan

electricity system. In addition, the Agency has very limited powers for improving the productivity of fuel and electricity use, which is arguably the most important measure for reducing the environmental impact of energy use.

This risk averse culture (towards the Agency having a wider role in the more political aspects of sustainable development) represents a challenge to the Agency taking a more influential role in sustainable energy. Stimulating debate on this matter has constituted a challenging component of my work.

[7] See Pearce, D. et al (1989) *Blueprint for a Green Economy,* Earthscan

3 DEVELOPING A VISION OF SUSTAINABLE ENERGY

3.1 My Role as Sustainable Energy Researcher

A key aspect of my project work has been that of acting as the Environment Agency's sustainable energy researcher over the past two years. Through researching energy issues I have also become the Agency's renewable energy and energy efficiency expert, and have thus acted as a source of information within the organisation. I have researched renewable energy and have written the Agency's Renewable Energy Policy Position.

Although the Agency houses some specific expertise on the environmental implications on various aspects of energy provision due to its pollution control duties, the Sustainable Development Unit recognised that it does not have a good understanding of energy efficiency potential or of renewable energy. Thus, the Agency needed to bring in this expertise before it could develop a holistic and informed position on sustainable energy. Through my work as an energy researcher it has been my responsibility to do this. However, for much of the past two years the additional structures necessary to take forward and embed this research in the organisation, have not been in place. With the support of the Sustainable Development Unit, I have therefore faced the additional challenge of developing ways by which to share and convey this information with the rest of the organisation. The organisation has not provided the Sustainable Development Unit with a clear mandate for researching and writing an Agency energy position – the structure of the organisation means that no single department has had the authority to do this alone. Unfortunately, my project proposal for an inter-functional group to establish energy policy for the Agency did not succeed in winning political backing. Therefore, the internal structure for developing an Agency energy policy did not exist and we engaged in an ongoing process of seeking to develop an audience for my research work. In the end (over a year into my project work), I embarked upon writing a vision of sustainable energy using my large body of research material, and the expert help of Walt Patterson[8]. We hoped that this vision document would be substantial,

[8] Walt Patterson, Associate Fellow of the Royal Institute of International Affairs, is a recognised expert on energy and environment issues who has written a number of books and was awarded the 2000 Melchett Medal by the Institute of Energy.

comprehensive and original enough to make the organisation sit-up and listen. My sustainable energy vision has achieved this aim, and it is rigorously researched and supported by primary research undertaken by others (please see Appendix 1). Although, there are aspects of originality in the energy vision – not least the actual compiling of an holistic energy vision – it is largely an amalgamation of other institution's research. Nevertheless, there is also a fair amount of argument presented in the energy vision, which is supported by other institutions' research findings and analytical work. This material is all found in Appendix 1.

3.2 The Need for Consensus on Sustainable Energy

As outlined above, delivering sustainable energy will be a key ingredient of achieving sustainable development. However, it became apparent to me during my first year at the Environment Agency that there was no consensus in the organisation over the meaning of sustainable energy. This was causing a severe blockage to the development of an Agency energy position. A point of particular disagreement was that of whether nuclear power is required in order to deliver a climate-friendly energy system – i.e. whether nuclear power is essential for addressing climate change (nuclear power is a carbon dioxide-free energy source). A key objective of my research has been to shed light on this issue, and specifically to assess whether energy productivity improvements and renewable energy resources would be able to deliver the energy services required by modern society.

Clearly, the opinion that nuclear power is needed to reduce carbon dioxide and combat climate change is poles apart from the opinion that renewable energy and energy efficiency represent the solution. The sustainability implications of these two alternatives are also fundamentally different. I was also deeply troubled by the opinion that nuclear power is necessary for combating climate change because of nuclear power's substantial negative sustainability implications. These negative impacts have been well documented over the last fifty years so that nuclear power is extremely unpopular and most western European countries have phase-out programmes for their existing nuclear capacity. Until the Bush administration took office in the USA, France was almost the only developed world country to look favourably upon nuclear power. The problems with nuclear power include the lack of an agreed disposal method for high level radioactive waste, a long and uncertain

decommissioning process for old power stations, the problems of nuclear proliferation and increased transport of radioactive materials under increased use, and the potential threat of a nuclear disaster (low likelihood, but extremely severe consequences). These issues are developed further in the energy vision in Appendix 1. It has not been my objective to undertake a detailed investigation into the sustainability implications of nuclear power as many others have already done this. These sustainability problems are also well accepted, and nuclear power is extremely unpopular across most of the developed world. Indeed, most nuclear power advocates agree that nuclear power brings substantial problems, and they only promote it as a long-term energy source because they claim that society has no choice. They argue that renewable energy and energy efficiency improvements simply have not the capacity to reduce carbon dioxide to the necessary long term levels required for a stable climate. Thus, they contend that society faces a dichotomy: either we have climate change or we seek to manage the problems associated with the large scale use of radioactive material. However, my energy vision sets out to prove that this is a false dichotomy. In addition, it is fair to say, that very few people would place nuclear power within a vision of a truly sustainable society – unless they genuinely had no choice.

My research aimed to address the scepticism of the pro-nuclear camp and those who were simply unsure of the best way forward by assessing the potential of energy efficiency and renewable energy. Delivering sustainable energy will indeed be a great challenge, and therefore it is not surprising that there was, and is, scepticism over the ability to reduce carbon dioxide emissions without nuclear power. As I have outlined below (and go into detail in the Project Activity section), following my research into energy efficiency and renewable energy I have become extremely enthusiastic about the great potential for delivering massive carbon dioxide emission reductions without the need for nuclear power. It is for this reason that I set out to put together a vision of a truly sustainable energy system – and one that consigns nuclear power to the rubbish heap of history.

3.3 The Need for a Vision of Sustainable Energy

As outlined above there is a lack of consensus on sustainable energy because many people are confused by the uncertainties and unknowns surrounding an energy

transition, and the substantial challenges associated with increasing energy productivity and renewable energy output. Our energy system is also very disparate and complex and it is difficult to visualise how all the components of a sustainable energy system would come together to deliver the energy services that we require. I determined that the best way to overcome these problems would be to paint a detailed picture of how a sustainable energy system could work. This would help piece together the complex and varied components of energy use and it would help people to see past the present uncertainties and unknowns towards the longer-term solutions for sustainable energy. I was also surprised to discover that no-one else had developed a sustainable energy vision. Even knowledgeable energy experts could benefit from a vision that fits together all the components of an energy system into a functioning whole, and illustrates how new technologies could work together to deliver the services that we all take for granted today.

The response that my energy vision has received outside the Agency – in the energy policy community – illustrates that I was correct to identify the need for a detailed vision. My work has certainly filled a gap and provided value to the energy debate (see project impact section below).

3.4 Developing the Sustainable Energy Vision

My understanding and opinions on sustainable energy have developed substantially through my research and development of the sustainable energy vision. In the project activity section of this report I go into more detail outlining the specific experiences, interviews and reports that helped develop my understanding, and the key lessons that I learned. I also document how my understanding of sustainable development as a whole has developed, and my new appreciation of the importance of applying vision, and the ability to visualise how things could operate differently in the future.

Writing the vision was quite a challenge, and I needed to investigate the technical, environmental, social and economic aspects of energy provision and use. My original plan was for a range of experts specialising in different aspects of sustainable energy to all contribute to a sustainable energy vision document. However, in the end I produced the whole document myself. This may actually have delivered a stronger document, because although I wasn't able to cover the wide

range of issues with the same level of authority, I was able to produce a complete vision with internally consistent arguments. I took on board a range of Agency staff's opinions (in particular, those of the review panel – which is outlined below), and external experts (in particular, Walt Patterson), in developing my thinking on sustainable energy and in developing the energy vision.

4 SUSTAINABILITY POLICY DEVELOPMENT IN THE AGENCY

4.1 The Role of the Sustainable Development Unit

The Sustainable Development Unit is a small policy development unit located within the Environmental Strategy Directorate in the Head Office of the Environment Agency. In addition to leading the Agency's understanding of, and contribution to, sustainable development, the Unit deals with many issues that "fall between the cracks" of the Agency's statutory functional responsibilities and the ways in which these are narrowly defined. The Unit works on a whole portfolio of issues as well as acting as an agent for change in the organisation. It has lead the Environmental Vision process, which has included the production of the Vision document and its accompanying Frameworks for Change. As I am a member of the Sustainable Development Unit, my project work has been housed within the general activities of the Unit. My manager, Chris Newton, Head of Sustainable Development, has the responsibility for strategically leading on energy issues for the Agency. My project work has constituted the main vehicle for strategically developing the Agency's contribution to sustainable energy, and therefore all my activities have been undertaken under the guidance of, or in collaboration with, Chris Newton (and thus, all the activities outlined in chapter 5 below have been undertaken with his guidance or involvement). All the members of the Sustainable Development Unit contribute towards the general aims and key messages of the Unit and support each other's work where possible – particularly where specific work objectives are overlapping or similar, and when team members come up against a particularly difficult challenge. Regular team meetings constitute the main forum through which problems are raised and shared. As I have worked closely with the rest of the Sustainable Development Unit throughout the project, the involvement of other team members is not documented in the coverage of the key issues – much of which focuses on the challenges involved in changing Agency attitudes and practices outside the Unit. The other Unit members are listed in Appendix 5.

The Environmental Strategy Directorate (ESD) is a small Head Office Directorate responsible for providing long-term strategic guidance to the rest of the organisation. However, the ESD's small size increases its challenge in influencing the strategic direction of the organisation and the work of the other much larger Directorates.

These challenges are even more magnified for the Sustainable Development Unit. At the beginning of 2000 the ESD identified four core cross-cutting issues facing the Agency. Over the past year it has begun "re-focusing" its work and activities so as to strategically develop the Agency's capacity to manage and address these issues. Energy is one of these key cross-cutting issues, and the Directorate has been tasked with strategically leading on sustainable energy for the Agency. My project work has constituted the main vehicle for taking forward the Directorate's approach to developing the Agency's capacity to contribute to sustainable energy in the UK.

4.2 Policy Advocacy: A Means of Taking Forward the Agency's Contribution to Sustainable Development

In my role as Policy Development Officer in the Sustainable Development Unit I have worked on developing key cross-cutting issues for the Agency at the national (corporate) level. In my first year in the organisation I worked on climate change issues in general, and was project-manager for an internal Agency report entitled, "The Implications of Climate Change for the Environment Agency". During the production of this report it became clear to me that in order for the Agency to take forward it's contribution to reducing greenhouse gas emissions it needed to develop an advocacy role for sustainable energy.[9] The Agency has a fairly limited ability to influence carbon dioxide emissions through its regulatory powers, and thus adopting a policy advocacy role at the national, regional and local levels would expand its ability to have an impact on energy-related greenhouse gas emissions.

Thus, my project has had an important advocacy component in its own right because it has sought to stimulate the Agency to develop a position on sustainable energy so as to take forward its capacity for shaping energy practices in the UK. My work has covered a fairly wide remit because it has involved taking forward the Agency's ability to develop policy on a complex sustainability issue. As I have outlined above, there are a number of staff who believe that the Agency should not develop policy positions on wider sustainability issues, but should instead concentrate only on specific operational issues. They argue that until the Agency has mastered the core of its statutory responsibilities (and can demonstrate that it delivers its specific

statutory duties in the most effective and efficient way possible) then the Agency should not become involved in other environmental areas. The Sustainable Development Unit has constantly challenged this opinion, and my initiative has contributed to this process. The Agency's current regulatory-focused approach fails to recognise the importance of the wider sustainability debate and also the resources available in the Environmental Strategy Directorate for progressing these areas.

The Sustainable Development Unit has played a prominent role internally in seeking to encourage the Agency to increase its involvement in the UK sustainability debate through adopting a policy advocacy approach. Over the final year of my project activity, the Unit has been running a specific "policy advocacy project" which has aimed to encourage the organisation to adopt policy advocacy as a sustainable development tool and to develop the organisation's capacity to develop and disseminate advocacy messages. My work has tied in closely with this initiative, which has been co-ordinated by my colleague Philip Douglas, and in working together we have helped progress the objectives of both projects. Another small head office Directorate, the Corporate Affairs Directorate, manages the Agency's interactions with the outside world. Clearly Corporate Affairs have a significant role to play in managing the Agency's involvement in sustainability policy debates, and in developing a strategy for how best to go about doing this. However, because the actual policy development itself has been left to the Environmental Strategy Directorate to lead on, I had only marginal involvement with the Corporate Affairs staff when promoting sustainable energy policy messages and the need for a more developed policy development process in the Agency in the early stages of the project. Over the course of the past two years, the Corporate Affairs Directorate have become more and more engaged in the policy advocacy agenda for the Agency, particularly due to the policy advocacy project. The Corporate Affairs Directorate is now developing a policy advocacy strategy – this increases the importance of creating a sufficient policy development process as a means for producing the messages for the Agency to advocate. These represent substantial changes in the Agency that have occurred during the course of my project.

[9] Fossil fuel use for energy provision is responsible for over three-quarters of UK greenhouse gas

Nevertheless, the Agency will face a number of challenges when it adopts its new policy advocacy approach and its participation in the national sustainability policy development process. The organisation will need to sensitively charter its voyage into this new arena, and some of the organisation's caution is well founded. The Environment Agency is a government body and its parent department is the Department of Environment (now housed within the Department of Environment, Food and Rural Affairs - DEFRA). Although the Agency is largely independent, it is a part of government, and therefore its role is essentially to help deliver government policy and objectives. The Agency needs to manage its policy advocacy in an intelligent manner so that it can justify its involvement in terms of providing expert advice to government, and of contributing to sustainable development, its main statutory duty. Nevertheless, this is likely to be a difficult path to tread, and there are certain to be skirmishes with staff in DEFRA who will see the Agency as over-stepping its mark. Indeed, DEFRA have already made clear their dislike of the Agency venturing into wider realms, beyond its specific regulatory duties; they took a very close interest in the development, and final wording, of the Agency's Environmental Vision publication. This illustrates another type of politics that will accompany the Agency's involvement in policy advocacy – namely, the power struggles between different parts of government, and the government departments' desire to control the activities of the Agency. However, it might be possible for the Agency to use policy advocacy to strengthen its relationship with DEFRA, and seek wherever possible to support and promote DEFRA messages, and thereby support DEFRA in its power struggles with other government departments and the conflicting interests that they seek to progress.

4.3 The Policy Development Process within the Agency

The Agency has a policy development procedure for its specific functionally focused policy, but lacks the capacity for developing policy on wider sustainability issues. Historically, the Agency has only produced policy on specific technical issues related to its statutory duties, and has never developed policy on those issues which lie outside its immediate remit and which involve subjective decision-making. This lack of decision-making structure has proven to be a significant barrier to developing

emissions (DoE, 1997) *Climate change – The UK Programme,* HMSO, London

Agency policy positions and progressing the Agency's contribution to key sustainability issues, such as energy.

It has not been clearly defined who in the organisation (or which Directorate) has the responsibility and authority for progressing the Agency's policy position on complex sustainability issues. These issues fall outside the specific remits of the Agency's functional duties and therefore end-up residing with the Environmental Strategy Directorate (ESD). However, even if the ESD has wished to develop policy on these issues, it has not necessarily had the authority to do so. Although the ESD and Sustainable Development Unit have a recognised mandate to "lead" on cross-cutting issues, they have not had a recognised mandate to develop Agency policy on these issues. The main challenge has been that there is no recognised route by which to develop sustainability policy. Over the course of my project work this has been changing, and now the Agency is close to realising a complete and formalised route by which to develop cross-cutting policy.

Throughout most of my project work, the only outlet through which the Sustainable Development Unit has been able to develop policy on wider sustainability issues has been through official Agency responses to government, or government-related, consultations. The Sustainable Development Unit capitalised on these opportunities so as to successfully develop robust Agency positioning on climate change, energy and other issues. Over 1999 and 2000 the Unit compiled Agency responses to the different stages of the Government's evolving climate change programme, and to the Government's renewable energy programme. These consultation responses represented the only messages of substance that the Agency had publicly made on climate change and energy until the summer of 2001. These consultation responses follow an official route within the Agency and are formally signed off by the Chief-Executive and Chairman, and thereby become official Agency policy.

There have been few other ways of developing policy on sustainability issues. An alternative route is directly through the Board or through the Board Advisory Groups (BAGs). However, it has been difficult to find space on their agendas and BAGs are not really designed for undertaking this policy assessment role. The Sustainable Development Unit has taken a couple of proposed position statements to the

Resources BAG over the past year and it has been clear that the BAG has been unsure as to how it should deal with these policy positions, and what its responsibility should be. Although, the Resources BAG passed the renewable energy position statement on the Agency's behalf in April 2001, it would not have been able to manage the greater complexities and controversies contained within a full sustainable energy advocacy position.

Another key problem has been the lack of priority allocated to policy development by staff in other Directorates. We need to involve the expertise and opinions of staff in Environmental Protection and Water Management in developing energy policy positions if we want the Directors to even consider these policy statements (after all, Environmental Protection have responsibility for waste and pollution policy). However, Environmental Protection staff have other work priorities, and often do not engage in this policy development, regardless of multiple encouragements to do so. The only way we (the Sustainable Development Unit) gained buy-in and a contribution from Agency staff in developing the renewable energy position was by stating that the policy statement was an item to be considered in an upcoming Board meeting. If we had not focused their attention in this way they simply would not have engaged because their other work would have taken priority. And yet if they had not participated then senior managers would have refused to even consider the renewable energy position.

Throughout the duration of my project I have sought to highlight this lack of a decision-making structure, and the barrier it presents to cross-cutting policy development. The Sustainable Development Unit promoted the idea of an Energy Task Force as a forum through which to develop an Agency energy policy (this is covered in more detail in the Project Activity section below). Although an energy task force, or similar decision-making structure, has not been established, the Agency has now recognised that it needs a formal route for developing policy, and it has established a senior management Policy Group for assessing policy gaps and vetting draft policy positions. However, this policy group represents just one-half of the complete structure that is ultimately required – the Agency has yet to map-out the process for actually developing inclusive policy positions on controversial sustainability issues, before the policy is reviewed by the policy group.

5 LITERATURE REVIEW

5.1 My Ideological Background

Before I successfully completed the Masters in Professional Studies in Leadership in Sustainable Development with Forum for the Future[10] I completed a BSc in Environmental Economics and Environmental Management. These study programmes have been primarily responsible for shaping my knowledge and understanding of sustainable development, although my interest in environmental issues goes back well into my childhood. Thus, I began this doctorate programme well grounded in the theory of sustainable development and the environmental challenge facing society. The Leadership in Sustainable Development programme was particularly helpful in developing my understanding of the practical implementation of sustainable development in the UK, with its emphasis on experiential learning with regard to implementing sustainable development in six key sectors of UK society. My time at the Environment Agency has further honed my technical and operational understanding of sustainable development.

It is now widely recognised that we need to change the way our society and economy operate so as to address environmental (and social) problems and deliver a sustainable future. This view has now been acknowledged by government, demonstrated by the fact that it has published its strategy for sustainable development[11]. However, this is not to say that there is a universal commitment to sustainable development, a universal understanding of sustainable development or universal agreement about how to deliver sustainable development. On the contrary, both understanding of, and, commitment to sustainable development is generally low. There are also significant differences of opinion on how to deliver sustainable development, even between environmental professionals. My understanding of sustainable development may be described as too radical by some environmental practitioners, and not radical enough by others. Many Agency staff do not recognise sustainable development as requiring such profound system changes as I do, or are

[10] Forum for the Future is a registered charity that works to promote a solutions oriented approach to sustainable development. It runs a scholarship programme in leadership in sustainable development with the Centre for Work Based Partnerships in Middlesex University

[11] The Stationery Office (1999) *A Better Quality of Life: A Strategy for Sustainable development for the UK*

not aware of the many opportunities for change – particularly since their approach to environmental improvement is regulation, and they may not be so in touch with the many other approaches to sustainable development. My understanding of sustainable development is that it requires fundamental market, institutional and social changes (brought about by key policy changes, for example, environmental tax reform, that can deliver for example, dematerialisation of the economy) – which is in line with the understanding advanced by Jackson.[12] This is an understanding that concentrates on the root causes of sustainability problems and incorporates changing the systems that drive and govern our economic activities. Other peoples' understanding may focus more on less-far-reaching change, such as the end-of-pipe control that currently dominates the main regulatory duties of the Environment Agency.

I have therefore approached energy policy with a focus on the environment as opposed to the conventional focus on sufficient energy supply for economic activity. This is not to say that I have disregarded the vital importance of energy services to the functioning of modern society. On the contrary I have spent a lot of time looking at how energy services can be improved since this often goes hand-in hand with improving the environmental performance of energy use. However, I believe that our use of energy should be redesigned so as to reduce environmental impacts to a minimum regardless of the challenge that this presents.

Prior to this project I worked on climate change issues for the Environment Agency for a year and a half, and during this time my interest in directing energy policy as a means of addressing climate change grew. For this reason I consider climate change to be the main energy-related environmental issue, and the main environmental driver for changing our energy system.

5.2 Survey of Sustainable Energy Literature

My technical understanding of sustainable energy has developed significantly over the past few years. The bibliography accompanying this doctoral thesis lists the main information sources that have informed my work, which has included books, reports, magazine articles, conferences and discussions. However, below I have briefly

[12] Jackson, T. (1996) Material Concerns - *Pollution, Profit and Quality of Life*

outlined the key documents that have helped shape my developing understanding of sustainable energy.

- "Natural Capitalism"[13] provides one of the most complete visions of a sustainable economy that I have come across. It contains many examples of quite radical energy efficiency and resource efficiency improvements and it also provides a model of how the powerful forces of the market place that are currently driving environmental destruction could instead be harnessed into powerful constructive forces for environmental protection. My background in environmental economics has provided me with a similar vision of an environmentally sustainable market economy that recognises the value and vital importance of environmental resources and which uses the dynamics of the market place to develop environmental technologies and services. This book has helped develop these ideas much further. This book demonstrates that radical energy efficiency gains are not only possible, but are normally economically beneficial when people have the innovation to find them, or when the market place is corrected so as to reward resource efficiency gains.

- "Factor Four"[14] concentrates on documenting the vast opportunities that are available for improving the resource and energy productivity of developed world economies. It contains many extremely inspiring examples of efficiency gains of up to a factor of four and beyond. The simple message of the book is that these examples of best practice could, with the right policy measures, become normal practice and that these efficiency gains could therefore be multiplied across the economy millions of times.

- "Transforming Electricity"[15] provides a superb introduction to how our electricity system currently works, and also outlines the opportunities available for making significant changes and reducing its environmental impact. It powerfully demonstrates that there is no need to consider our present electricity system as the only model for doing things, and that the real way of reducing the

[13] Natural Capitalism, Lovins et al, Earthscan 1999
[14] Lovins et al (1998) *Factor Four – Doubling Wealth, Halving Resource use*, Earthscan
[15] Patterson, W. (1999) *Transforming Electricity – The Coming Generation of Change*, Earthscan

environmental impact of electricity is to change the nature of the system. This introduced to me the opportunities available for transforming our electricity system, and the way that many people are unable to "think out of the box" when considering how to reduce the environmental impacts of electricity. The book provides powerful arguments for sweeping away the foundations upon which the renewable sceptics and the pro-nuclear lobby base their claims.

5.3 The Royal Commission on Environmental Pollution's Energy Report[16]

The Royal Commission on Environmental Pollution's energy report has been the single most important information source for my work, and the energy vision draws heavily upon its research and conclusions. The Royal Commission undertook a two year study into the environmental impact of human energy systems and the options for the future, and this report is the information source that has had the biggest impact upon my understanding of what constitutes sustainable energy. The report begins with an assessment of climate change and the urgent need for a reduction in greenhouse gas emissions. It argues the case for a 60% reduction in carbon dioxide emissions by 2050 (based upon IPCC recommendations) and that this corresponds with a 60% reduction in fossil fuel use. This sets the stage for the need for an UK energy transition. The report goes on to provide an excellent coverage of the UK energy system and the great potential for reducing energy use in all sectors and for bringing on stream renewable energy. It is probably the best single document available in terms of its coverage of the potential for improving the energy efficiency in all our energy applications.

The Royal Commission report provides a sound and reasoned assessment of renewable energy and energy efficiency potential. This type of assessment was exactly what I was looking for in my own appraisal of sustainable energy for the Environment Agency. I have been happy to accept the judgement of a fairly large group of environmentally-motivated, but nevertheless meticulous, and fairly cautious, people who benefited from a huge range of evidence from experts in the field. I felt that the tone of the report was very positive and outlined the vast array of opportunities available for changing our energy system.

[16] Royal Commission on Environmental Pollution (June 2000), *Energy – The Changing Climate*

Although the Royal Commission report fails to officially recommend a specific energy path for the UK I feel that the flavour and the substance of it's analysis and discussion does in fact clearly reveal a preferred energy vision. The report quite clearly concentrates on energy efficiency improvements, the increased deployment of renewables and the introduction of new technologies such as fuel cells and heat pumps. It recommends that Government does all it can to enable the development of these technologies and that it educates the public about the need for these changes. It effectively rules out nuclear power for the time being by declaring that "there should be no new construction of reactors until a solution to the nuclear waste management problem is identified to the satisfaction of both the scientific community and the general public". It is unlikely that such a solution (and one that pleases all!) will be found in the near future.

It approaches the analysis of energy at the overall system level and looks at how the UK energy system could be changed to be more efficient and to better accommodate the characteristics of renewable energy. The Royal Commission produced four alternative scenarios illustrating how the UK might meet its energy needs in 2050 whilst still reducing its fossil fuel use by 60%. The scenarios are based upon different combinations of energy efficiency gains, renewable energy and nuclear power. I believe that it would be possible to build upon these four scenarios so as to quantitatively illustrate that it is feasible to reduce fossil fuel use by 60% whilst still delivering the energy services we need without the need to resort to nuclear power.

The report contains many useful perceptions. The Royal Commission believes that there are no grounds for believing that it will be totally impossible to power UK society in a fossil fuel limited future without the contribution of nuclear power. It also argues that although achieving an energy transition constitutes a Herculean task, this does not mean that it is impossible, or that a pessimistic, sceptical response is warranted.

6 METHODOLOGICAL APPROACH

6.1 Research Methodology

6.1.1 An Action Research Approach

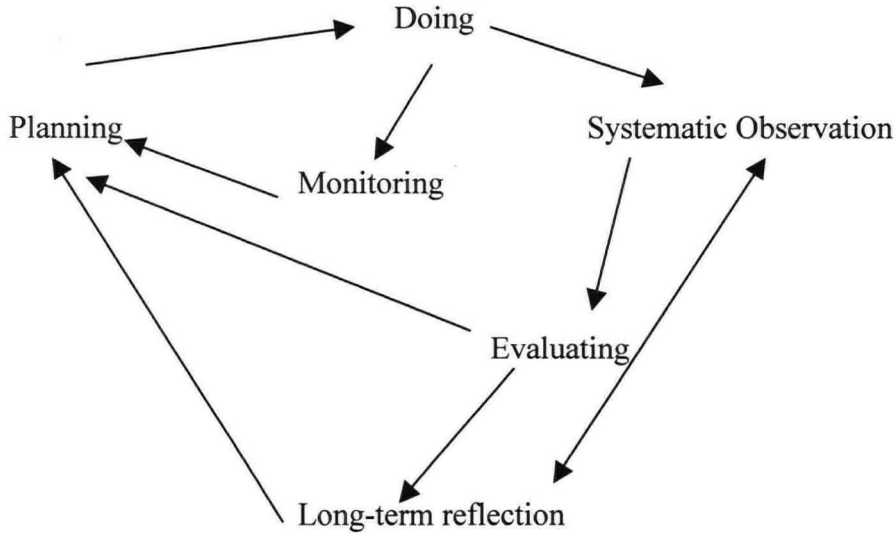
I have adopted action research for my overall approach to stimulating the Agency to develop an energy position. In the event of undertaking the project work I found that the situation changed regularly, and I needed to adapt to the new conditions in order to take forward my project aims; that of researching and writing an holistic and robust vision of sustainable energy for the UK, and stimulating and provoking the organisation to consider the need for an Agency energy policy, and the content of that policy position. I also needed to take advantage of all the opportunities that came my way to promote my cause. I have constantly evaluated my success (or lack of success) and then re-adjusted my approach accordingly. The dimensions and boundaries of my project work have changed a number of times so that I have needed to re-evaluate some of my methods and strategic actions – as is made clear in the Project Activity section below.

Action research has been the most suitable approach because of the dynamic nature of my project work and the need to constantly re-assess and plan my activities in an effort to deliver my project objectives. As Coghlan et al[17] says:

"Action research is an approach to research that aims at both taking action and creating knowledge or theory about that action."

I have sought to continually assess my actions and then plan how to do things differently in order to more effectively influence the Agency's understanding of sustainable energy and its deliberations over policy advocacy. In many respects this is the approach that I adopted during the research and development of the sustainable energy vision and the Renewable Energy Policy Position as well as the approach I followed for encouraging the Agency to develop an energy policy position. This approach has enabled me to work in the "messy real world of practice".

[17] Coghlan, D. & Brannick, T. (2001) *Doing Action Research in Your Own Organisation,* Sage



This diagram[18] illustrates the complexity of the dynamic cyclical research approach and highlights the different tiers of reflection in practice. The inner loops illustrate the regular reflection in practice, and the outer loop, the longer term reflection. The general cycling process of planning, taking action, evaluating, further planning and new actions can thus have many tiers of complexity. This approach is useful for managing the evolving interactions within the Environment Agency that have accompanied this project. Continuous reflection has constituted a very important tool in my work, as is outlined in the research techniques section below.

I have not had complete control over many aspects of the actions that I have sought to undertake. Many of the activities relevant to my project have depended upon decisions and activities taken by others, in particular senior management. This is the challenge and complexity involved in collaboratively contributing to organisational change, and seeking to influence a dynamic, evolving and large organisation. I have not been able to implement (or see implemented) a number of the policies and changes (actions) that my assessment has led me to believe appropriate. These issues are brought to life in my project activity section below. However, I was able to determine the most suitable discussion papers to prepare and feed into internal thinking processes, and also the direction of my energy research and the evolution of

[18] Griffiths & Morwenna model – from McNiff et al (1996) *You and Your Action Research Project,* London Routledge

the energy vision, following my interviews and meetings with Agency staff and external experts.

There has been a significant collaborative element to the action research and a number of other parties have participated in evaluating the actions and helping plan the new approach and activities. This has included my review panel (see below), my manager and the Sustainable Development Unit as a whole who have all fed into the action research cycle (see project activity section).

6.1.2 Other Methodologies

I originally intended to adopt the case-study method as an approach to trialing workshops and evaluating their effectiveness in involving Agency staff in policy development on complex issues. However, in practice the Agency senior management decided not to establish a wider decision-making structure for the development of inclusive, common-ownership policy positions. Therefore, I had no mandate to hold workshops (and for staff to allocate time for participation) and, even for the two that I did organise, the proceedings had no outlet because I had no mandate to develop policy in this way. The survey approach, although suitable for my research into sustainable energy, would not have the flexibility for managing the more dynamic and interactive organisational elements of the project. Although there have been some observational aspects to my research – such as my observing senior management decision-making – the ethnographic approach would not have been a suitable overall approach for managing the core elements of my energy research and my highly active interactions with the organisation at large.

I have not opted for soft systems methodology to evaluate the rich detail and complexity of the interactions and systems within the Environment Agency because this has not actually been an objective of my research. As Checkland puts it:

"Soft systems methodology is a process of inquiry into problem situations in human affairs."[19]

[19] Checkland & Scholes (1991) *Soft Systems Methodology In Action,* Chichester Wiley

Although soft systems may prove useful in evaluating and aiding the change process with the organisation (and thereby illuminate organisational change for sustainable development) this would have been well beyond the scope of my work. I feel that the action research approach has proved adequate for managing the interactions of my project with the change process in the organisation, and that it has helped me cope with the dynamic situation and successfully identify activities for moving forward.

6.1.3 Research Tools

The project has involved both quantitative and qualitative research, but the bulk has been qualitative. Although I investigated the potential for reducing fuel and electricity use in the UK and the capacity of renewable energy to power our energy services, this involved gathering the work of others and evaluating it. This evaluation has been largely qualitative in nature. My research has primarily been desk based and I used unstructured interviews and professional consultation (a list of the key interviews is found in Appendix 6). I also undertook fieldwork in the form of consultations with energy experts and Environment Agency staff. This is documented in the project activity section below.

My main research technique has been documentary analysis, making use of library-based, policy-focused and organisationally-based documentary research. I have obtained this information from specialist government research establishments, government departments, Universities, published books and journals and from campaigning environmental organisations. In my study of sustainable energy I have undertaken secondary analysis of data and material collected by others. This is because I have sought to develop an holistic vision of sustainable energy, and have therefore needed to cover a very wide cross-spectrum of issues ranging from renewable energy to energy efficiency potential across all energy uses. The main way in which I have added value to the sustainable energy field is to put together all these different aspects of human energy use so as to develop an holistic picture of how energy efficiency, renewable energy and more sustainable fossil fuel use can come together to deliver a successfully functioning high performance energy system.

Much of my initial research took place through a literature survey of the vast wealth of material which covers the different aspects of energy. This was the best approach for enabling a holistic analysis of energy production and use whereby I pieced together the various aspects of the energy debate. I did not undertake primary research; for example, it would be impossible, and unnecessary, to undertake an entire analysis of the technical potential of all renewables, and besides the expertise for this resides elsewhere. For the fieldwork aspects of my work a survey approach was also suitable for enabling me to obtain the views and expertise of a large number of Agency staff and external experts.

I have also derived a great deal of insight and understanding by networking with key individuals from the research and policy community, and internal staff with expertise covering different aspects of energy provision and use. I have undertaken a number of semi-structured interviews with senior Agency staff to obtain their views on some of the key issues relevant to my research (namely the role of the Environment Agency and their opinions on sustainable energy). My interviews with senior staff covered a complexity and depth of material that went well beyond the limits of a questionnaire. These also tended to concentrate on the subjective and political aspects of sustainable energy which it would be impossible to tease out through the use of a questionnaire. As is common with action research, my interviews were not simply to acquire information and data, but also, often more importantly, to seek to influence the interviewee. I have also discussed specific details concerning sustainable energy with specialist authors.

I have relied heavily upon the use of a learning diary during my research. Primarily the learning diary has helped as a tool for reflection, but it has also provided other roles, such as charting progress towards my project aims, gathering data for analysis, and as an aide-memoire to activities. I have found the learning diary to be an extremely effective way of reflecting on my activities, and also my evolving understanding of sustainable energy.

6.2 Critical Approach to the Research

I have sought to critically assess the information that I have gathered because energy policy involves speculating about the future and therefore has to deal with a large

number of unknowns and uncertainties. For this reason energy articles and reports tend to be strongly influenced by individuals' own value judgements. For example, energy analysts consider how energy demand might change in the future and how new supply technologies might develop over time. This is a very difficult exercise and invariably time has shown energy analysts to be very wide of the mark. In particular I have looked for:

- Whether the assumptions upon which a piece of research is based are flawed, for example, they may omit key variables that might greatly affect the outcome;
- Disagreements between different authors or research findings, and the differences in interpretation that these disagreements are based upon;
- Whether all the relevant information has been put into an analysis;
- Whether authors/ researchers apply a fair weighting to the different requirements of energy policy, and in particular the need to radically improve energy productivity;
- Whether authors/ researchers have employed a visionary approach to their analysis and where they are stuck in an out-dated way of thinking, and fail to appreciate the opportunities for change;
- What vested interests the researchers/ authors might have – particularly important in the energy debate where there can be powerful industrial vested interests.

All my research outputs have been channelled through the Environment Agency, and my Review Panel has been a useful critic of my work. The Review Panel consists of six Agency staff members with expertise covering different aspects of energy. The panel includes:

- Neil Davies, Policy Advisor for Process Industries Regulation whose interests include taking forward the Agency's contribution to improving the environmental performance of electricity generation.
- Peter Douben, Strategic Issues Manager, who worked with me on energy issues until he left the Agency in May 2001, and who was seconded to the Royal

Commission on Environmental Pollution and was an assistant secretary on their energy report.

- Colin Foan, Technology Assessor who is responsible for assessing the environmental implications of different technologies and for assessing the potential of new technologies for contributing to environmental protection/ sustainable development.
- Jimi Irwin, Head of the National Centre for Risk Analysis and Options Appraisal whose responsibilities include providing technical support for strategic issues, such as those relating to energy
- Chris Newton, Head of Sustainable Development (my manager) who leads on energy policy for the Agency, and is also a member of the Department of Trade and Industry Energy and Environment Foresight Panel.
- Ronan Palmer, Chief Economist who is responsible for the Agency's policy on, and interaction with, economic instruments and has a particular interest in energy policy.

There have been a number of benefits associated with being work-based during this project, such as the opportunity to access a large number of experts both within the Environment Agency and externally in the energy community. In addition, I would not have been able to understand the organisational complexities and thereby successfully take forward my project aims without being a worker researcher undertaking a quasi-action research approach. I have also acquired the recognition of many Agency staff, and external contacts, as the energy policy expert within the organisation. There have been no conflicts with regard to my position within the Sustainable Development Unit because the Unit exists to stimulate and provoke new thinking and strategic direction in the organisation, and others in the Unit play a similar role to my own. However, there have been a number of challenges to my work within the organisation at large - the main one being the decision of senior managers not to establish and resource an Energy Task Force which could have developed energy policy on the Agency's behalf. A number of Agency staff have also been hostile to my opinion and ideas, and particularly the message that the Agency needs a position on energy and an internal structure to develop that position.

Although challenging, I have found my position as worker researcher extremely stimulating. The dynamic demands of working in an evolving situation – and the need to react, plan and actions and re-evaluate – has been extremely helpful in developing my own understanding and approach to sustainable energy. Without the stimulating internal debate it is unlikely that I would have identified the need for a sustainable energy.

6.3 Managing Ethical Issues

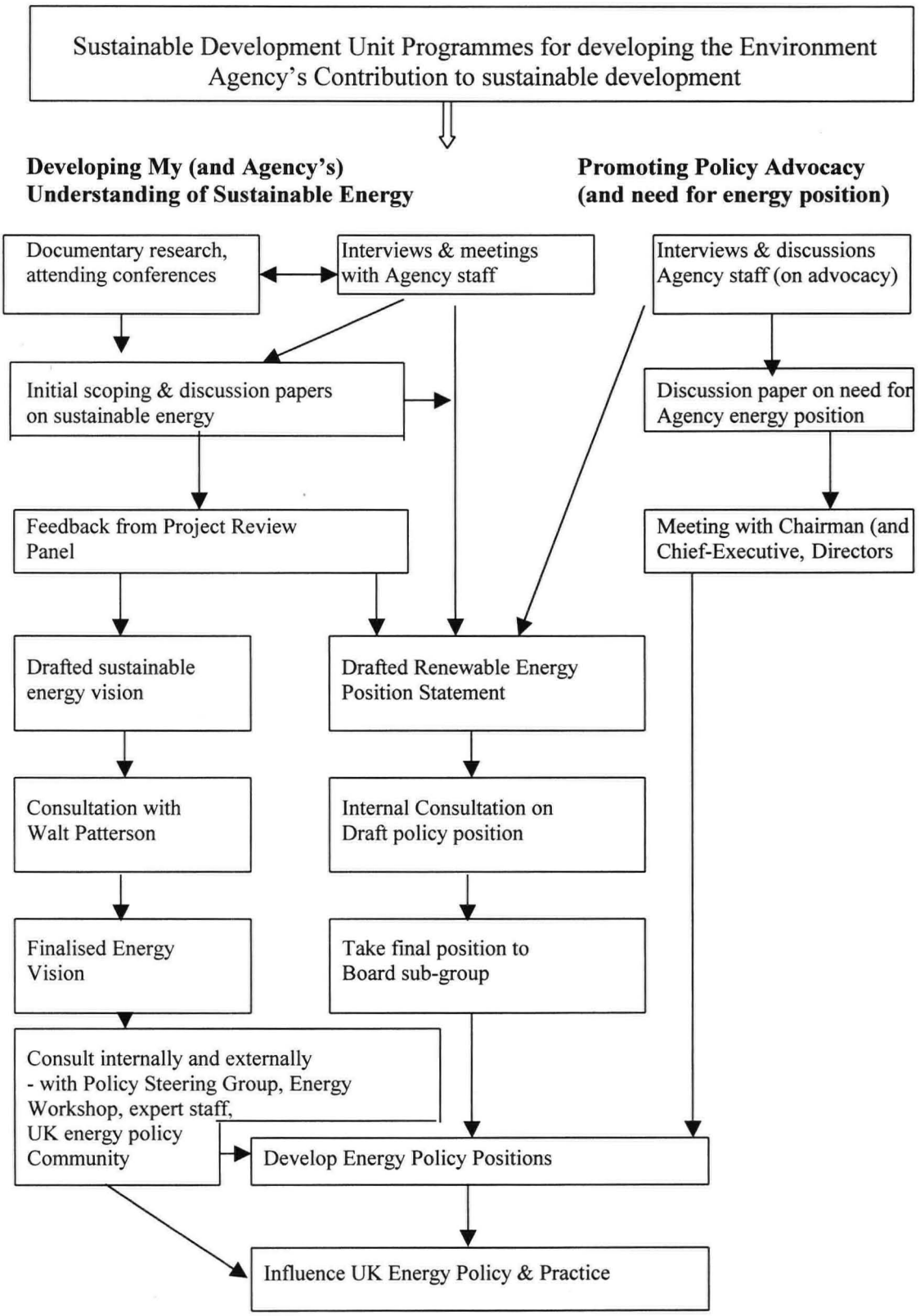
There have been a number of ethical issues associated with my research. These have been concerned with the politics surrounding sustainable energy and the differences in opinion concerning the best options for the future, and stimulating the organisation to think about its future role in delivering sustainable energy. Many people feel quite passionately about these issues and I have needed to be sensitive in managing differences in opinion. Nevertheless, this is a general characteristic of sustainable development issues and they are invariably political. My project work has challenged the Environment Agency to think about sustainable energy issues and its own role in the development of sustainable energy systems in the UK. The key purpose of my project work has been that of trying to increase the Agency's participation in the national sustainable energy agenda, but there are many Agency staff who do not want the organisation to participate in the external energy debate in this way - and, as a result, I have met some inertia. Thus, by undertaking this research project I have directly participated in an internal debate about the future positioning of the organisation and the ways in which it can best contribute to sustainable development. There have been many sensitivities associated with this, not least the requirement for me to show respect for other peoples' opinions, particularly those who are older and more senior than me. I have found it challenging to develop an approach that has allowed me to keep pushing my arguments without aggravating the staff around me.

I have been careful in handling the confidentiality issues which have arisen in my discussions with internal and external contacts. I have also been careful not to betray other staff members' trust when they have spoken to me in confidence.

The ethical issues surrounding the Environment Agency's increased participation in the climate change and energy debate are highlighted and explored in section 4.2 above. Other ethical issues integral to the overall aim of the project are also explored in other sections of this report, such as the issues surrounding the Sustainable Development Unit's efforts to stimulate change in the rest of the organisation so that it can improve its contribution to sustainable development.

7 PROJECT ACTIVITY

7.1 Flow Diagram of Main Approach and Project Activity



7.2 Developing my Understanding of Sustainable Energy

7.2.1 My Developing Understanding of Sustainable Energy – The Importance of Vision and Harnessing Innovation

Along with my intensive research, my interviews and discussions with Agency staff have had a powerful influence upon my maturing opinion on sustainable energy, and the ideas and arguments presented in the sustainable energy vision. The key interviews, meetings, and workshops of my project activity are outlined in appendix 6. This highlights my interviews with Directors, the Chief-Executive and Chairman, and some other interviews with Agency staff who have specific energy related expertise. However, my general interactions with Agency staff, including discussions and meetings going back to when I started at the Agency, have all helped to build up a picture of the general understanding, and opinions on, sustainable energy in the Agency.

My conversations with Agency staff has demonstrated that, for many people, the potential for change is simply not enough when considering the future of our energy system. There exists a prevalent attitude of scepticism concerning the potential of energy efficiency improvements and renewable energy, and a sneaking doubt that they will be unable to deliver a satisfactory energy system. It seems fair to conclude that this corresponds with a scepticism that society can actually change, and a deep-rooted doubt that sustainable development can actually take place. I believe that this scepticism lacks vision and a willingness to take risks (of the unknown) when making change. Neither does it complement the innovative and entrepreneurial approach that is so fundamental to sustainable development. In its report "Energy – The Changing Climate" the Royal Commission on Environmental Pollution summed up this positive approach well. In reference to the substantial opportunity for change (so as to address climate change) it quoted Charles Dickens, from "A Christmas Carol",

"Are these the shadows of the things that Will be, or are they shadows of things that May be, only?"

It also strikes me that this scepticism towards the potential for change in our energy system is failing to grasp the scale and elemental nature of the changes that are needed. This cynicism about economic and societal change fails to recognise the staggering unsustainability of our current way of doing things. The realism we should acknowledge is that sustainable development requires us to transform the way that we do things and that small cosmetic changes will not be sufficient for delivering a sustainable society.

This scepticism could be driven by the fear of change – perhaps society demands unmitigated proof that change can successfully take place, before it has the courage to actually engineer the transformation. It appears that vast potential and opportunity for change are simply not enough to dispel this cynical response. This demand for perfect information on how the change process will successfully pan out appears to hold strong even when discussing time-scales of fifty years and more.

Confronted by this scepticism, I began searching for clear answers to these questions and doubt. The challenge that appeared to lie before me was that of answering every detail concerning how the UK economy could be powered by renewable energy alone. However, unsurprisingly, I failed to manage this, and over time began to realise that such a research objective could never be satisfied, and, that in fact, it fails to comprehend an important element of sustainable development. It is impossible to know all the answers to the many environmental challenges that face us. Sustainable development is a process of learning and exploration, and the solutions will reveal themselves over time and need to be tried and tested.[20] Under this understanding of sustainable development the challenge of sustainable energy is indeed one of bringing to reality the great potential for vastly improving our efficiency of energy use, and increasing renewable energy output. Indeed, it is unrealistic to believe it is possible to accurately predict what our energy system will look like in fifty years – imagine having tried to undertake that task fifty years ago.

[20] See section 2.2 for an account of my understanding of sustainable development as a learning process of change. See, *An Analytical and Descriptive Model of Sustainable Development for the Environment Agency,* Environment and Society Research Unit, UCL, 1999

This understanding of sustainable energy does not fit well with the traditional research approach to energy policy which aims to clearly demonstrate what is possible, and what is not possible, tomorrow – based upon technical, economic, social and environmental criteria. It is impossible to clearly assess what sustainable energy (renewable energy and improved energy productivity) can deliver simply because we can only guess at the technological, economic and social changes that will occur in the future. This traditional approach is far too cautious and does not embrace the innovative and entrepreneurial spirit that is vital to sustainable development. This evolving understanding of sustainable energy has taken shape in the energy vision document in Appendix 1.

As is outlined above, I approached my research with a bias towards renewable energy and energy efficiency as the best means for reducing the environmental impacts of human energy use. My research has further strengthened this opinion. My investigations have revealed the exciting, vast array of potential solutions for advancing these two areas and for reducing carbon dioxide emissions from our energy system. In particular, numerous opportunities exist for improving the efficiency with which energy is produced, transported and used. I am very heartened by this vast potential and the positive light it casts over the whole sustainable energy debate, and the sustainable energy vision attempts to communicate this substantial potential.

7.2.2 Interviews with Agency Staff

Appendix 5 lists the key interviews, meetings and workshops both within the Agency and with external bodies, and it also includes a sample of the questions and issues that I raised. My interviews with Agency staff had two objectives. The first was to explore their views about the Agency's wider role in contributing to sustainable energy, and the second to tease out their opinions over what constitutes sustainable energy – from this I hoped to get a feel for how difficult it may be to obtain consensus on an Agency energy policy position. It was extremely informing to hear their views on the matter.

These interviews were very useful in honing my own understanding and views on sustainable energy. Most significantly they have helped develop my understanding

and convictions that sustainable development is a challenging process of change for which we have yet to develop all the answers. As outlined above, this personal understanding of sustainable development has been reinforced and crystallised through my undertaking this project work, and discussing sustainable energy with Agency staff.

It has been interesting to note how, in the face of anthropogenic climate change and the need for urgent reductions in greenhouse gas emissions, people are still highly cautious about developing robust opinions on how we should use and provide energy. A commonly voiced opinion is that there simply is not enough information available to us to develop a vision of sustainable energy. Certainly, there exist a number of uncertainties and unknowns, but at the same time we do not have the luxury to procrastinate about the best way forward and declare the need for more research. It is surprising that people should react this way when the need for action is so pressing and the opportunities for change are so clear.

7.2.3 How I Approached my Energy Research and the Development of the Energy Vision

There are many issues contained within an analysis of sustainable energy and the sheer breadth and complexity of these issues means that it is very difficult to get a good grip on the topic area. Nevertheless, it is vitally important that all these issues are covered because otherwise we are not equipped to make a sound judgement on what constitutes a sustainable energy system.

My research sought to address precisely this challenge. After three months of documentary research of energy issues it became clear that I had passed the useful stage in terms of acquiring knowledge that would help to formulate my energy opinion. My intensive research was not targeted enough and after covering the main issues I was in danger of drowning in the massive quantities of material covering energy. I therefore decided to plan my written outputs and to target my research on material that would be useful for my discussion papers. Although I was aware that it would be difficult to use the huge amount of available information to synthesise a coherent analysis of the sustainability of different energy systems, getting started on my discussion papers would help structure my research work.

I decided that the best approach would be to write a general introductory paper about sustainable energy and the myriad issues that need to be considered, and then to use this as a foundation for mapping out my approach to developing a sustainable energy vision. I set about writing my first paper, "A Sustainable Energy Future – A Snapshot of the Issues". This paper was designed to stimulate and inform Agency discussions over a sustainable energy position, and I particularly wished to promote the development of a sustainable energy vision. Writing the paper proved to be an extremely useful exercise in helping clarify my own understanding of sustainable energy and fully scoping all the issues that need to be considered.

My Project Review Team assessed the paper and the contribution it made to the sustainable energy debate as it was occurring and evolving in the Agency. Although they found it an interesting read, they felt that it was not the document to take the debate forward within the Agency. I had also found the document very difficult to write, and realised that I prefer to write opinion pieces rather than discussion documents. I therefore determined that my next sustainable energy paper would be more provocative, and would take the argument to the reader, and to the Agency, rather than simply discussing the issues. I decided to try and take forward consensus building and policy development by experimenting with an argued paper on sustainable energy, and the position that the Agency should adopt. I determined that this approach would be more effective because by presenting the arguments it would force a reaction from the Agency, and also force it to consider the issues.

The Energy Review Team were fairly interested in my taking forward the analysis of the environmental sustainability of different energy sources, and to compare, for example, the environmental impacts of nuclear energy with the those of the different renewable energy sources. They were also interested in further research to shed light on the combined environmental impact of different renewable energy sources under a renewables intensive energy system. However, in my opinion these are not the most important steps necessary for taking forward the Agency's contribution to sustainable energy. My interest lay in the Agency developing opinion on the key issues of current energy policy, and to increase its support for renewable energy and energy efficiency. I felt that an energy vision would focus minds on the energy

system of the future and the policy measures that are needed today in order to deliver that energy system. Excessive concern over the environmental impacts of renewable energy is a little premature considering the piffling amount of renewable energy use in the UK, and besides, researching these issues would have required more analytical, and primary, research than I would have had time to allocate.

I therefore began drafting the sustainable energy vision as the best means by which to provoke the Agency into developing a robust energy position, and also, as a powerful way for the Agency to make an impact on sustainable energy in the UK. However, I was concerned that my expertise and knowledge of the full width of issues that would need to be covered was not extensive enough to do the vision justice. I felt that an excellent vision could be put-together if experts specialising in housing energy performance, electrical appliance efficiency, the different renewable energy technologies, combined heat and power, energy management, and the economics of energy efficiency and renewable energy all came together under the editorial-ship of a general energy expert. I felt convinced that working alone would fail to deliver the degree of quality that collaborative work could produce. However, although I had made a number of good contacts across the energy community I was not in the position to command the interest of half a dozen recognised experts so as to co-ordinate a high profile research project. Besides, to have done so would have required far more time than that available to me, and also the Agency. Thus, circumstances forced me to approach the project myself, along with the expert advice of Walt Patterson.

Although confident that a coherent, and even quantified, vision could be produced, I nevertheless was quite unsure how it would turn out. It was certainly a learning process and I needed to overcome a number of obstacles in putting it together. One such challenge was that of attempting to paint a detailed picture of a decentralised electricity system. I needed to provide a more complete description than my research had revealed, and so combined information on computer control systems, electricity networks, energy storage technologies, fuel cells and combined heat and power to produce something quite original. I was very keen to take forward this area, and demonstrate what could be possible, because it is a severe blocking point for many people (who I would argue are unable to think "out of the box") who are unable to

visualise a sustainable energy system. Although my energy vision aims to keep within the boundaries of what is possible with known technologies (whilst nevertheless being visionary in terms of what they could achieve) I was surprised and enthused by the levels of potential emission reductions that could be achieved. The energy vision attempts to provide some quantification of the energy balance in 2050, and the reductions in fuel consumption delivered by the various efficiency improvements and the contribution of different renewable energy sources. Nevertheless, this energy balance could be quantified far more accurately if the time, resources and expertise was put into it. The vision could then be made more robust and clearer in how it delivers carbon dioxide reductions – although some artistic license would still be required in order to quantify the fuel reductions that a general dematerialisation of the economy could deliver.

Developing the energy vision has substantially increased my knowledge of renewable energy and energy efficiency, and the policy measures required to deliver their potential. And, perhaps most importantly, whereas at the beginning of my research I was somewhat negative and pessimistic about climate change and the challenge of sustainable energy, I am now far more positive about the potential for delivering a truly sustainable energy system.

7.3 Promoting Agency Policy Advocacy on Sustainability Issues

7.3.1 The Challenge of Influencing a Large Organisation

My project has aimed to contribute to the work of the Sustainable Development Unit, and the general objectives of the Environmental Strategy Directorate, in influencing the organisation with regard to its involvement in sustainable energy and its opinion of what constitutes sustainable energy. As outlined above, the Agency has laid out its intentions to change the way it delivers its contribution to environmental protection and sustainable development in England and Wales in its Environmental Vision. The majority of my project work was undertaken alongside the development of the Vision, and in many ways my project was before its time because it has sought to implement the kinds of changes championed in the Environmental Vision. Unfortunately the time-scale for completion of the Vision slipped, and it was not published until towards the end of my project work.

Along with the Environmental Vision there have been a number of "organisational change initiatives" taking place within the Environment Agency over the course of my project. These initiatives have focused on improving the Agency's delivery of its statutory duties, and general improvements to the functioning of a large organisation, such as improved knowledge management. Thus, these initiatives will probably only have a minor impact upon the changes needed in order to become a more opinionated, sustainability solutions lead organisation. However, the overall feeling of change generated by this range of initiatives, the Environmental Vision and the arrival of the new Chairman and Chief-Executive has had a positive impact in preparing and directing the organisation towards a more policy advocacy role.

Although it is difficult to assess the individual impact that my work, within the Sustainable Development Unit, may have had upon the organisation, I have outlined below my key activities in promoting the need for Agency policy advocacy and for a coherent sustainability policy development process. This has included interviews with senior staff (the key interviews are listed in Appendix 5), policy papers and the promotion of my, and my Unit's, opinion whenever the opportunity has arisen.

7.3.2 Promoting the Need for an Energy Task Force

My initial project proposal described an Energy Task Force that would act as the cross-functional decision-making body for determining the Agency's energy policy position, and it outlined my role as secretariat for the task force and the main energy researcher in the organisation. However, unfortunately, a Sustainable Development Unit paper to Directors failed to persuade them of the need for the task force and it was not established.

Thus, early on in my project it became clear that the component of my work dealing with developing the Agency's capacity to develop energy policy was likely to become even more challenging. In light of this, I decided to adapt my second paper into a provocative document arguing the case for the Agency developing an energy position. Paper 2 was entitled, "The Role of the Environment Agency in Sustainable Energy – The Need for a Policy Position". The Sustainable Development Unit attempted to widely distribute this paper, and I proactively sought the comments and

advice of my review panel in terms of the quality of this paper and its potential for stimulating thought and provoking action. I also sent the paper to the Chairman in advance of my meeting with him. I continued to use this paper throughout the duration of my project work to push the case for establishing an energy task force. It is difficult to assess the impact I may have had upon the Agency's senior staff in promoting this message. My discussions on the matter with two key Directors and the Chairman may have influenced their opinion – I explore this in more detail below.

Over the course of my project work my opinion has strengthened that the Agency urgently requires an Energy Task Force – or at least some kind of decision-making structure for determining an energy position on the Agency's behalf. The organisation has been unable to develop energy policy advocacy positions because it currently has no process by which to do so. Nevertheless, the Agency has not yet installed the internal decision-making structures that I believe will be necessary. The Agency's senior managers seem to believe that the Agency should develop its energy policy advocacy positions based upon its expertise in pollution control and environmental management. As I outlined above, because the Agency's duties cover only certain aspects of energy provision, the organisations' understanding and knowledge of sustainable energy solutions is far from complete and, in fact, without bringing in new expertise and understanding the Agency is not in a good position to pass judgement on sustainable energy policy. Nevertheless, specific research projects will not directly deliver the material for policy advocacy. Science and research is not able to pin point the best policy solutions for sustainable energy by itself – judgement of the facts is needed in order to do this. This is clearly the case in terms of the nuclear power debate – coming to a decision on whether the UK needs to expand nuclear power as a means of helping to reduce carbon dioxide emissions requires subjective judgement of a wide range of issues and information. However, I am uncertain whether the senior management appreciate that the development of sustainability advocacy positions will depend upon the interpretation of science and information – it is this application of subjective judgement that requires a decision-making process.

At this stage I am unsure how the Agency will come to a decision on the content of its energy policy. It is most likely that senior managers and Board members will have the say on the content of the policy, and that somehow they will thrash out an opinion that satisfies each of them. I hope that the messages in my energy vision strongly influence their opinions – things are looking promising on this front because many of them have already read my vision, it has received good reviews and the Chairman wishes to use it in developing the Agency's energy policy advocacy positions.

7.3.3 Discussing the Agency's Role in Sustainable Energy with the Chairman

I organised a meeting with the Chairman fairly early on in the course of my project work in an effort to take forward the case for the Agency developing an energy position as the first step in developing its contribution to sustainable energy. Previous to this meeting I had spoken to two Directors and the former Chief-Executive, Ed Gallagher (Barbara Young became the Agency's new Chief-Executive at the end of 2000), and they had all dismissed the idea of the Agency developing sustainable energy advocacy positions that challenged government policy. These meetings demonstrated the scale of the challenge involved in developing the Agency's leadership role in sustainable energy and in cultivating an audience for a sustainable energy vision. Prior to our meeting the Chairman had read my discussion paper which presented the case for an Agency energy position and an energy task force. I was pleased to hear the Chairman state his agreement that the Agency needs to develop policy advocacy positions on sustainable energy. He wanted the Agency to use its expertise to bring something new to the energy debate, and he made clear his wish for an Agency position to be well backed up by good science. He also stated his wish for the Agency to use energy as the topic area to pioneer more active participation in the UK sustainability policy development process.

Nevertheless, the Chairman and I did not agree on everything. He was not persuaded by my argument that the Agency should develop a vision of sustainable energy in order to take forward the Agency's understanding of sustainable energy and as the best way by which to make an impact on UK energy policy. I explained that there is a lack of consensus on what constitutes a sustainable energy system, and that this

formed a barrier to progress on energy advocacy positions for the Agency, and a barrier in the UK energy policy community at large.

Shortly after our meeting the Chairman issued a memo to Directors asking them to take forward the Agency's capacity to develop energy policy advocacy positions. This suggests that I had a positive impact on the Chairman, and raised the profile of developing an energy position in his mind and also make it clear that the process for doing so needed to be worked upon.

7.3.4 The Agency Pushes Ahead with Sustainability Policy Advocacy

The year 2001 has been fairly momentous for the Agency because over the course of the Spring the organisation has decided that it will definitely enter the realms of policy advocacy on key sustainability issues. The organisation is now setting out to develop its capacity for policy advocacy as a means of contributing to sustainable development. The momentum of the preceding years, and the key changes in the organisation, such as the new Chairman, Chief-Executive and the launch of the Environmental Vision, have gradually worked to change the organisation so that it is now ready to enter the political arena of sustainability policy making. The Sustainable Development Unit's policy advocacy project has, and is, also playing a key role in taking forward the Agency's entry into sustainability policy advocacy. It is quite fascinating to note how the Directors that I spoke to just a year and a half ago at the beginning of 2000, have now changed their minds and are supportive of the Agency's developing opinions on issues well beyond its specific remit.

Through promoting the arguments for policy advocacy via my papers and interviews I have played my part within the Sustainable Development Unit, in contributing to this process of change. This seismic shift in approach for the Agency also suggests that in some ways my project has been marginally before its time. If I had begun the project one year later then I would not have faced as many challenges for progressing my work. If the organisation had been receptive to the idea of developing an energy policy position from the beginning then I could have focused all my attention on developing the energy vision and taking forward the decision-making process in the organisation. However, looking at it another way, it could be said that I have definitely been in the right place at the right time. For if the

Sustainable Development Unit had not made the energy vision available to the organisation when it did – when it was ready for it in the summer of 2001 - then the organisation might have adopted some other understanding of sustainable energy. It appears that because the energy vision has got there first, my opinions (as shaped and developed through research, and interactions with Agency staff – particularly the rest of the Sustainable Development Unit – and external experts) on what constitutes a sustainable energy system may have a powerful influence over any future Agency advocacy on energy and climate change. I discuss this issue in more detail below.

7.4 Developing the Agency's Renewable Energy Policy Position

7.4.1 Recognising The Need for a Renewable Energy Position

In my role as the Agency's renewable energy expert and information source for Agency staff, I was aware of the Agency's involvement at the regional level across England and Wales. There have been a number of regional renewable energy scoping studies across the country, and the Agency has been a partner in each of these. However, the Agency staff participating in these regional fora have required guidance on the Agency's opinion and policy on renewable energy. A key purpose of these regional initiatives has been to promote the sustainable expansion of renewable energy and to stimulate a planned approach which includes community involvement. Essentially, these Agency staff required a robust policy position on renewable energy that also outlined the Agency's opinions on the potential negative environmental implications of the different renewable energy technologies.

In addition to this useful driver, the Sustainable Development Unit was already keen to develop an Agency position on renewable energy because of the negative opinions exhibited by some Agency staff towards renewable energy and the confusion surrounding the definition of energy from waste as a renewable energy source. I wished to develop a clear Agency position that promoted the substantial sustainability benefits of renewable energy so that the Agency conveys powerful support for renewable energy regardless of the personal opinions of some Agency staff. Through co-ordinating the Agency's response to a government consultation on renewable energy policy, the Unit had already developed a number of Agency

messages on renewable energy when. I now intended to take forward these messages and develop them into a robust and comprehensive policy position.

I also undertook research on the sustainability of renewable energy sources in collaboration with The Natural Step UK[21]. This research work took the form of a workshop which included Environment Agency staff and external experts. I then worked collaboratively wit Dr Mark Everard, Director of Science at the Natural Step in developing the output of the workshop into a joint Environment Agency and Natural Step report.[22] This research, and the final report, has been an extremely worthwhile assessment of renewable energy, and I used the conclusions of this report in developing the Agency's renewable energy policy position.

7.4.2 Establishing A Process for Developing the Position

I spent some time carefully drafting a renewable energy position statement, so that it was strongly supportive of renewable energy whilst also recognising that the expansion of renewables needs to undertaken in a sensitive way so that environmental impacts are minimised. I then consulted on the position statement with a number of Agency staff who had a particular interest in, or expertise in, various renewable energy technologies, and who represented each of the functions (the key areas of the Agency's work). Unless the Sustainable Development Unit ensured buy-in from all of the functions then we would upset some parts of the organisation, and the renewable energy position would probably not be accepted by senior managers. However, we needed to raise the profile of the renewable energy position statement in some way in order to stimulate these Agency staff to allocate the time to reviewing it. As it was also the first time that policy on a cross-cutting issue had been developed, we had to invent a process by which to obtain official approval for the policy statement. We therefore declared to all the consultees that the renewable energy position statement was soon to go to the Board for consideration. This did the trick and I received an overwhelming response with extensive comments from almost every consultee.

[21] The Natural Step UK operates a science-based learning and decision-making programme aimed at helping organisations to understand and apply the concept of sustainable development. I approached the Natural Step because I wished to bring in their expertise and sustainability model for investigating the sustainability of renewable energy, and they had already held a seminar with the Environment Agency investigating the issue of genetically modified crops.

Drafting a renewable energy position that pleases everyone has proved to be a very difficult job. However, there is no doubt that the process improved the robustness of the position statement and also my understanding and knowledge of renewable energy, and how to undertake the sustainable expansion of renewable energy. As I expected, the main point of disagreement centred around my treatment of the net sustainability benefits of renewable energy, and the high-level principle adopted in the position statement of prioritising the environmental benefits of renewable energy over its perceived environmental impacts. Many Agency staff who are concerned about the landscape impacts of renewables were not happy with this bold approach. Although we refined the position statement so that it was more sophisticated in its treatment of the net sustainability of renewable energy, and the need for the sensitive development of renewables, we were not happy with the amendments called for by a number of the consultees. We therefore decided to keep the main messages and philosophy of the position statement as they were, and to list those arguments and opinions presented by the consultees' that were not incorporated into the paper.

The paper was deemed too experimental and low priority to make it to the full Board meeting, and so it was instead channelled through the Resources Board Advisory Group (a sub-group of the Agency's Board). This brought the Renewable Energy Position to the attention of senior managers and was also a means of getting the position statement formally adopted by the organisation. The Resources BAG was clearly impressed by the fact that a renewable energy position statement had been produced and were pleased that the Environmental Strategy Directorate were taking forward cross-cutting policy development. It was also clear that the item was rather new for the BAG and they did not know entirely how to deal with it. Nevertheless, they successfully took the process forward by adopting the role of a policy review body prior to Agency adoption. They recommended that a few amendments be made to the document and asked to see the amended paper at their next meeting. Along with the rest of the Sustainable Development Unit, I was pleased because they were generally happy with the main arguments of the paper, and the Agency taking a supportive approach to renewable energy. At their next meeting the BAG formally

[22] Renewable Energy: A Sustainability Analysis Using the Natural Step Framework, September 2000

adopted the renewable energy position statement, and the Agency had their first comprehensive policy piece on a cross-cutting issue.

7.4.3 The Impact of the Position

The renewable energy position has had a significant impact upon the organisation. It has particularly influenced a key aspect of policy for the Agency – namely its position on energy from waste incineration. However, stimulating the organisation to think about its energy from waste policy has also forced it to consider the issue of waste incineration as a whole. The Agency has not yet developed a comprehensive and robust position on waste incineration even though waste regulation is a core aspect of its work, and waste incineration is considered to be a key emerging environmental issue in the UK. Government policy treats mixed municipal waste as a renewable energy resource, such that waste incineration with energy recovery gains the same favourable policy treatment as the other true renewables such as wind power. However, mixed municipal waste is not a renewable energy resource, and the treatment of energy from waste as a renewable resource has the effect of taking subsidy and other support away from the true renewables and bringing renewable energy as a whole into disrepute. (The Renewable Energy Position itself explains these arguments – see Appendix 2). The development of the renewable energy position paper lead to extensive deliberations with the Agency's waste regulation staff and the eventual agreement on a robust position on energy from waste. It has also stimulated the waste staff to take forward their position on waste incineration generally – which will be vitally important for the Agency and its reputation as a competent, expert body in the field of sustainable waste management.

The renewable energy position also had a key impact upon the Agency's opinion on, and treatment of, small-scale hydropower. Small-scale hydropower projects in streams and rivers (these are only small power generators and do not have barrages) tend to be considered outside the Agency as environmentally friendly energy schemes that can generate electricity for many years at little or no environmental cost. However, before a developer can implement a small-scale hydropower scheme he or she will need to obtain numerous licenses from the Environment Agency related to the perturbation of the water course (such as water abstraction, flood risk issues, fish protection, and other ecological considerations). Whether justified or not,

the Agency has developed a reputation for being unnecessarily hostile towards small-scale hydropower projects. As this is the Agency's main interaction with a specific renewable energy technology, along with the rest of the Sustainable Development Unit, I felt that it was important for the Agency to develop a clear and comprehensive position on small-scale hydropower. I felt it was ridiculous that the Agency had not done so already – if the organisation does not make its position on the environmental implications of small-scale hydropower clear, then accusations that the Agency is a barrier to the development of small-scale hydropower are justified on these grounds alone. However, my interactions with water management staff failed to encourage them to develop a comprehensive position on small-scale hydropower, and the Agency still has an unsatisfactory involvement with the hydropower industry. The Agency is failing to contribute to the degree it could to resolving the development issues surrounding small-scale hydropower, and the future contribution of this energy source to clean power generation in the UK.

This interaction with water management and waste regulation staff encouraging them to develop policy positions represent two good examples of my work stimulating the organisation to consider the need for policy positions on complex sustainability issues, and working with the staff to actually develop this policy. It is also a good example of working on complex policy issues to seek to reach consensus, and therefore improve understanding and the Agency's capacity to contribute to these important areas of sustainability.

The renewable energy position has been used to brief the Chief-Executive for her meetings with external groups. But most importantly it has served its purpose as a vital resource for Agency staff dealing with regional renewable energy initiatives. The content of the renewables position has informed the Agency's engagement with regionally lead renewable energy scoping studies and subsequent development strategies, and I hope that it continues to ensure that the Agency acts as a positive force for renewable energy across the country.

7.5 Embedding the Sustainable Energy Vision Within the Agency

Once I had finished writing the energy vision in March 2001, I distributed it to the rest of the Sustainable Development Unit. I challenged them to consider the energy

vision, and whether it offered a model for how to take forward all the key cross-cutting issues in the Agency. I also highlighted how the energy vision followed the same principles as the Environmental Vision in developing a long-term vision to guide an outcome focused approach to environmental protection and sustainable development. The rest of the Unit responded very positively to the energy vision and the value it brought to the Agency's understanding of sustainable energy and the sustainable energy debate generally.

By the time the energy vision was completed in March 2001, attitudes had progressed sufficiently in the Agency so that it was now receptive to the idea of policy advocacy and the need for developing an understanding of sustainable energy. My manager decided that the best route by which to bring the sustainable energy vision to the organisation's intention was once again via the Resources Board Advisory Group (following the same route as the renewable energy position). As I have outlined above, the BAGs are not actually designed with the purpose of vetting policy or for providing advice on complex organisational issues, such as how to progress the energy vision within the Agency as part of a policy development process. Nevertheless, presenting the energy vision to this committee of senior managers drew attention to the question of how the Agency should take forward its intentions for energy policy advocacy and the best means by which to develop its energy messages. The Resources BAG were interested in the energy vision, and the concept of a vision to take forward understanding of sustainable energy. They therefore endorsed the use of the document as a means of stimulating an Agency discussion about sustainable energy. However, it was left to us to determine the process by which to undertake this internal discussion, or consultation, on a sustainable energy vision. I was a little concerned about the potential difficulty of undertaking discussions on the energy vision because it can be very difficult to encourage Agency staff to allocate time to these "extra-curricular" activities – particularly when the topic area is so large and complex. In addition, Agency staff would no doubt struggle to find the time to read the fifty page vision document. In the end, however, events proved these worries to be unfounded.

All the members of the Resources BAG, which included some Directors and board members, took away copies of the energy vision. We then distributed the energy

vision to a number of key Agency staff with a particular interest in energy, making sure to include all parts of the organisation. I requested that these staff consider the energy vision against the following key questions:

- Is the visioning approach useful for guiding policy development and does it fit well into the overall context and principles of the Environmental Vision?
- Does this energy vision match your own personal vision? What do you like and dislike about this vision?
- Are we likely to be able to reach consensus in the Agency on a shared vision of sustainable energy?

We hoped that this approach would enable the Sustainable Development Unit to undertake a selected consultation on the energy vision, and thereby have a range of opinions on the energy vision itself, and on how best to move forward in developing Agency energy policy advocacy positions. However, the energy vision's impact within the Environment Agency has been most successfully taken forward due to the external response to the document – which I explain in more detail below. The energy vision's positive reception by the UK energy and environment policy community, has significantly raised the profile of the document within the Agency. The energy vision has now been read by senior staff, including the Chairman, and there is general support for using the document as a foundation for developing Agency energy policy positions. Some of the vision may even be included in a future official Environment Agency energy policy document.

There still needs to be an internal consultation and development process so as to improve, and attain consensus on, the energy vision before it can become official Agency policy. The immediate challenge facing the Agency is to develop a process for undertaking this internal consultation. The main messages in the energy vision are forming the basis of an official Agency contribution to the Government's long-term energy review. However, many of these long-term sustainability messages are of a controversial nature and I am unsure how the final decision will be arrived at, or perhaps more importantly who will make the final decision. The main item of controversy is still the issue of nuclear power and whether the UK needs to expand

its nuclear capacity in order to deliver a climate-friendly energy system. A lot of complex issues, including many unknowns and uncertainties, need to be assessed and interpreted when coming to an opinion on this subject. And although I am content that there is no need to turn to nuclear power at this stage (and most likely never, if the UK totally committed itself to an ultra-efficient renewably powered energy system) there are many others in the organisation who do not have the same opinion. During a recent internal energy meeting based on the energy vision, it was clear that although my energy vision has helped inform the debate, there are still substantial differences of opinion on this issue. I am still uneasy that the Agency's senior management is failing to recognise that the key sustainability issues requiring leadership are those that are most controversial in terms of the best solutions for moving forward.

7.6 Influencing the UK Sustainable Energy Policy Community

At the same time as widely distributing the energy vision internally, my manager and I decided that it would be useful to distribute the energy vision to the external UK energy policy community so as to obtain their opinions on the usefulness of the document. We made it clear that the energy vision is simply a research output from the Agency which aims to stimulate discussion about the composition of a future low carbon sustainable energy system and is not (as yet) an official Agency document. We distributed the energy vision to over thirty organisations including environmental think tanks, environmental campaigning organisations, such as Greenpeace and Friends of the Earth, the energy utilities trade associations and the main two government departments responsible for energy policy.

The external response to the energy vision has been very enthusiastic. A number of organisations returned positive comments within a matter of days of distributing the vision, and within a week the Parliamentary Renewable and Sustainable Energy Group asked me to present the energy vision at their annual conference, which is a very high profile event in the sustainable energy policy calendar. When presenting the energy vision I was very clear to point out that it was simply an individual contribution to the Agency's internal energy debate and not an official Agency document. Nevertheless, it generated a lot of interest and enthusiasm from the conference delegates because a comprehensive energy vision has never been

attempted before and they were pleased that the Environment Agency (as an arm of government) was making a positive contribution to the sustainable energy debate and potentially providing useful leadership in the area. They certainly received the energy vision as if it will become an official Agency policy document in the near future – subsequent to improvements whilst still containing the same main technologies, themes and approach. This illustrates how my research is likely to successfully influence the content of Agency policy positions on sustainable energy.

Stephen Tindale, the Director of Greenpeace, spoke at the podium directly after me and he referred to my presentation numerous times, and commented that it was one of the most constructive and "joined-up" pieces of thinking on energy that he has heard from government (or an arm of government). A few other speakers added to this support, and numerous conference delegates were keen to speak to me afterwards. We also received an offer from the Director of the Centre for Sustainable Energy to work in partnership to further develop my work into a shared vision of sustainable energy. Thus, it is clear that the energy vision has contributed a great deal to the UK sustainable energy debate and my research work has already taken forward the Agency's contribution – even though the Agency has not yet got an official position statement on the matter. Greenpeace have since spoken of the energy vision at other events and used it to support their own arguments and messages.

Issuing the energy vision outside the Agency, without first agreeing it as an official position, has had the effect of taking the Agency into a whole new area (although when the Agency finally promotes an official energy position, the organisation will also be entering new, and far more significant, waters). The Agency in its Environmental Vision has spelt out its intention to work in partnership so as to progress sustainable development. A key way of doing this is to participate in sustainability policy making and to share, and take forward, thinking with the other bodies who are active in the debate. Partnership, in the important area of sustainability policy, involves precisely this, and the Agency can learn from others as well as contributing to others understanding. The Agency can also take forward the expertise and knowledge (and policy recommendations) of other smaller, and less high profile, organisations. I feel that the distribution of the energy vision and

the response and interaction it has provoked, is an experimental case study for the Agency in working in partnership in a new way to progress sustainable development. It is proving very challenging for the Agency to develop a policy position on sustainable energy, and it is clear that the Agency does not have all the expertise necessary for an holistic appreciation of sustainable energy. Therefore, it is sensible to share the thinking (in the form of my energy vision) with others, and to help their thinking through its experimental approach. In retrospect it would have been difficult for the Agency to contribute something as experimental and creative to the energy debate, if the energy vision had first required official approval so as to be a representative piece of thinking for the organisation at large. (Besides, in fact, the enthusiastic external response has significantly raised the profile of the energy vision – demonstrating that sharing the thinking with others has helped fertilise the debate within the Agency).

Other organisations routinely participate in the energy debate (and other environmental debates) by sharing their research and thinking with others, and in fact use this interactive process to develop their understanding and policy positions. This is exactly what the Sustainable Development Unit has done by sharing the energy vision with others. However, many people in the Agency have found it very difficult to understand or accept that the energy vision should have been shared externally even when it is clearly marketed as a research document to stimulate discussion. They argue that the Agency's name should not be associated with what is essentially an individual's opinion – regardless of whether the document is well researched and designed to stimulate thinking on a sustainable development issue. Of course, the Agency is right to be wary when sticking its toe in these waters. As a government body it must be careful in managing its relationship with government, and its parent department. As a public body it must also be very careful in developing is views so that it correctly protects, and stands up for, the environment on behalf of the public. And as a large government body that is only now entering these waters the media will be particularly interested in its views – especially ones that challenge government policy. Thus, the potential pitfalls for the Agency are fairly unique.

Although, the public affairs department has been concerned that external parties' will misperceive the energy vision as an official Agency opinion document (and, true enough, some have, regardless of the clear introduction to the paper), generally the organisation has been pleased by the response and the positive light it has shone on the Agency. The senior management has recognised that external bodies consider the Agency to have made a useful contribution to the energy debate through producing and disseminating the energy vision discussion document. Thus, they recognise that it is potentially a useful tool for contributing to sustainability thinking, and the organisation will in future be more geared up to managing the process and the response it generates.

8 PROJECT IMPACT

8.1 Assessing the Impact of my Work

As I have already outlined there has been considerable progress towards the delivery of my project aims over the summer of 2001, and the Agency has now opted for developing a policy advocacy position on energy to influence the sustainable energy debate and the national policy making process. My work is also substantially influencing the content of that evolving sustainable energy policy position, and there is significant likelihood that the Agency will adopt an official sustainable energy vision, and that my energy vision will form the basis of this. I consider these to be exciting developments in taking forward the Agency's contribution to sustainable energy. Although some of this success is due to my project activity within the portfolio of activities of the Sustainable Development Unit, much of it has come as a result of the general process of change that has been occurring in the Agency over the last few years, which has been carefully documented in this paper.

In seeking to contribute to the work programme and objectives of the Sustainable Development Unit, my project aims have been very challenging, and correspond with encouraging fairly significant developments in the organisation as a whole. Assessing the individual impact of my project activity is extremely difficult. Nevertheless, it is fair to say that my project activity has influenced the process of change in the Agency towards adopting policy advocacy as a tool for taking forward the Agency's contribution to sustainable development. My provocative discussion papers, conversations with Agency staff (and particularly senior staff), and participation in workshops and meetings all helped promote the message that the Agency needs to develop policy positions. However, the most significant impact of my project activity has been the shaping of the Agency's understanding of sustainable energy through the success of the sustainable energy vision and the renewable energy position statement.

The main progress towards the delivery of my project aims has come right at the end of my project work. It has taken until now for the Agency to fully commit to undertaking policy advocacy, and for developing sustainability policy positions, and

the sustainable energy vision was only launched (into this more favourable climate) in Spring 2001.

8.2 Impact Upon Agency Policy Advocacy and Policy Development Process

The Agency's attitudinal shift towards developing policy advocacy positions has been a great success. However, I feel that the change process in the Agency is not yet complete, and that in order for the organisation to successfully develop sustainability policy positions the decision-making process needs to be more fully developed. I have been disappointed that the Agency's senior management has not recognised the need for an energy task force, or a similar decision-making body, and it appears that the organisation has yet to fully appreciate that developing opinion on sustainability issues requires a process for managing subjective judgement.

For much of my project work the internal attitude concerning the Agency's potential involvement in policy advocacy, was a substantial challenge to my project activity. Much of the Agency was simply not ready for the ideas of the Sustainable Development Unit, or the development of an Agency energy policy position. Therefore, a great deal of my effort went into developing an audience for my work and changing attitudes in the Agency, and influencing the Agency's opinion on policy advocacy.

The following summarises some of the key ways in which my project activity may have influenced this change of opinion in the Agency:

- My continuing interaction with Agency staff throughout the project has stimulated them to think about the role of the Agency in sustainable energy, and the need to develop a shared understanding of sustainable energy to inform the Agency's work and its interaction with external stakeholders. I continually highlighted the inadequacies of the (as then) current situation and provided suggestions for taking forward the Agency's contribution.

- Influencing the Chairman - shortly after my meeting with the Chairman he issued a memo to Directors asking them to take forward the Agency's capacity to

develop energy policy advocacy positions.[23] This suggests that I raised the profile of developing an energy position in his mind and that I also made clear that there are insufficient structures for developing Agency opinion on complex issues.

- The discussion paper "The Role of the Environment Agency in Sustainable Energy – The Need for a Policy Position."[24] This paper for the first time explored the issue of Agency involvement in national sustainability debates and articulated the need for policy advocacy and the development of Agency policy positions. I distributed the paper fairly widely and it was read by the rest of the Sustainable Development Unit, several senior managers and other Agency staff interested in the Agency's contribution to sustainable energy. The Chairman read this paper before our meeting and it clearly influenced his thinking. Therefore, this paper probably played a role in shaping Agency opinion in this area, and contributed towards to the gradual movement towards policy advocacy.

- In producing the Agency's Renewable Energy Policy Position the Sustainable Development Unit established a process for developing cross-cutting sustainability policy in the Agency. We introduced a new approach and process to the organisation because the Agency had never before proactively developed sustainability policy. By taking the renewable energy position to the Agency's senior management we brought to their attention the need for improving the policy development process in the organisation. The Chairman actually commented on this very issue during the meeting when the Board Advisory Group considered the renewable energy position statement.

- The process of researching and developing the sustainable energy vision drew the Agency into consideration of the how the Agency could best participate in developing sustainable energy, and the need for an energy position. Disseminating the energy vision internally has also stimulated Agency staff (and the senior management) to consider more fully how the Agency could increase its involvement in the energy debate, and the challenge of achieving a shared

[23] This memo to the Chief-Executive and Chief Scientist is found in Appendix 7.

understanding and providing leadership. Distributing the energy vision to external parties has taken the Agency forward more quickly than its cautious nature may have liked. The external response has been a learning process for the Agency and has forced it to think more fully about how to participate in various aspects of the sustainability debate.

Over the final few months of my project activity the Agency has begun to install the internal structures that will be needed to successfully develop sustainability policy. A high-level Policy Steering Group has been established to improve the overall co-ordination of policy development in the Agency, by assessing gaps in the Agency's policy for advocacy and to assign the responsibility for policy development on a particular topic area to a senior staff member. However, the Agency needs to allocate further resources and establish additional structures, such as an Energy Task Force, in order to develop a balanced and inclusive energy policy (and other sustainability policy positions). As yet the Agency has failed to appreciate that the application of subjective judgement is required when coming to an opinion on sustainable energy.

8.3 Impact Upon the Agency's Understanding of Sustainable Energy

The sustainable energy vision has been widely read both internally and externally, and is likely to greatly shape the Agency's future energy policy positions. Although the original project proposal for an Energy Task Force to oversee the development of an inclusive Agency sustainable energy vision failed to take shape, it appears the Environment Agency may still develop and adopt an energy vision – albeit by a different approach. The Chairman has read the energy vision and outlined his support for developing the document into an official Agency publication which includes an aspirational vision of the future, and the policy recommendations for delivering this energy vision. The Chairman would also like to use the energy vision as the focus for an Agency hosted high level discussion seminar on sustainable energy to be held in the coming winter. The Chairman personally thanked me for producing the energy vision and the excellent foundation it provides for the development of an official Agency energy position. His memo is included in Appendix 6.

[24] This discussion is found in Appendix 3.

A number of Agency staff members have outlined their support for the energy vision and the general messages that it conveys. The energy vision has also been distributed to Board members and Directors. However, the process for taking forward the energy vision in the way desired by the Chairman has not yet been decided upon. And, therefore, I can not be sure whether the vision will remain essentially the same, and with the same general messages, or whether it will change substantially when being developed into an official Agency position document. The Agency has yet to have a comprehensive debate on the sustainable energy vision and the content of an official Agency energy position. Obviously, the large differences in opinion on sustainable energy that I encountered in the early stages of my project work are still prevalent in the Agency. As stated above, I am concerned that the Agency's senior management still appear to believe that points of disagreement over sustainable energy can be cleared up through good research. The future of nuclear power is an excellent example of an issue that can not be resolved in this way, and the organisation needs to establish a decision-making process that can accommodate differences of opinion based on subjective judgements. Whatever the final process, I hope the arguments and philosophies in the energy vision will remain fundamentally unchanged during its evolution into the Agency's official energy policy document, and its final suite of energy policy advocacy messages.

I am pleased that the renewable energy position statement is robust and highly supportive of renewable energy – even after managing to accommodate a variety of Agency staffs' comments and concerns. The renewable energy policy will now form the Agency's official position on renewable energy across England and Wales, and it should ensure that the Agency is generally supportive of renewable energy developments wherever they occur, regardless of any individual Agency staff member's personal opinions on renewable energy.

8.4 Impact Upon the UK Energy Policy Community

The sustainable energy vision has already taken forward the Agency's involvement in, and contribution to, the sustainable energy debate in an unexpected manner. The energy vision has been extremely well received in the UK energy policy community and the document has attained fairly high levels of publicity in these circles. As the

energy vision has emanated from the Environment Agency it has significantly raised the Agency's profile in the sustainable energy debate, and it has increased the Agency's reputation in the sustainable energy field. My presentation of the energy vision at the Parliamentary Renewable and Sustainable Energy Group's annual conference has also significantly raised its profile, and the involvement of the Agency in sustainable energy policy. The energy vision struck a chord with many of the conference delegates which suggests that it has filled a gap in the sustainable energy policy literature. Many of the conference delegates (who represented many different public, private and voluntary organisations working to deliver sustainable energy) conveyed their feeling that the energy vision provided leadership in sustainable energy, and that the Environment Agency was a well placed body to provide this leadership.

At the conference my manager and I were approached by numerous organisations keen to work in partnership with the Agency to further develop the energy vision. They communicated their interest in helping to develop a shared vision of sustainable energy for the UK. Thus, the energy vision has gathered a momentum of its own and has taken the Agency into the energy policy debate faster than its cautious nature would have liked. Through distributing the energy vision, the Agency has into engaged with a wide range of bodies working on various aspects of sustainable energy. This engagement with a sustainability policy community represents completely new territory for the Agency and it helps take forward a key element of the Environmental Vision – the Agency's intention to work in partnership to progress different aspects of sustainable development. Some important lessons can be identified from this external engagement on the energy vision. The Sustainable Development Unit has been unsure how to manage, or take forward, the external interest and offers for collaborative working. This demonstrates how the Agency is not yet prepared, or ready, for taking forward partnership work in this way. The Agency needs to develop a clear plan for how to respond to this type of external interest, and generally for collaborative working in areas beyond its specific regulatory duties. Hence, this provides an example of how the Agency needs to develop its capacity for delivering its ambitions for a new way of working.

A key reason for the high level of external interest in the sustainable energy vision is that it represents the first time the Environment Agency has substantially engaged in the sustainable energy debate. Thus, a large component of the energy vision's impact upon the wider sustainable energy debate probably emanates from the general interest in the Environment Agency's involvement. It is interesting to speculate as to why Greenpeace has been so interested in the energy vision. At a recent press launch of a Greenpeace renewable energy initiative, their Director, Stephen Tindale, mentioned the energy vision, and its aspirational target for 50% of the UK's energy needs to be met by renewable energy by 2050. This lead to the Guardian newspaper mentioning the energy vision in an article on renewable energy on the 2nd August 2001, which is shown in Appendix 6. Although it is clear that Greenpeace believe the energy vision brings real value to the sustainable energy policy debate, they are also strategically using the document to promote their own agenda – as a piece of Environment Agency research with which to influence and embarrass government?

The RENEW magazine[25] has produced a draft review of the sustainable energy vision, which has yet to be published. This review is very complimentary of the energy vision and outlines that as well as painting an holistic picture of how sustainable energy solutions could come together to deliver a successfully operating energy system, the energy vision is useful in, "generating positive enthusiasm as an effective way of overcoming problems and propelling society forward." The energy vision has not been distributed to any other magazines, journals or the general media.

The Government's Energy Review[26] team (based in the Performance and Innovation Unit at the Cabinet Office) have expressed their interest in the energy vision and requested more copies. On the 16th August Chris Newton and I visited the Cabinet Office and discussed the energy vision, and the issues it raises that are of interest for

[25] "Renew" is the bimonthly UK journal of the Network for Alternative Technology and Technology Assessment, and is produced by the Open University's Energy and Environment Research Unit.

[26] In June 2001 the Government announced its intentions to undertake a comprehensive long-term review of energy to the year 2050. The remit is wide and aims to provide a high level assessment of the success of present policies for delivering the government's economic, social and environmental objectives, and also better understand the long term options for energy provision and use. This energy review is being undertaken by the Cabinet Office and will report directly to the Prime Minister in the coming winter.

the government's energy review with some of the staff working on the review. Therefore, the document is in a small way influencing the government's long-term review of energy policy, and is essentially forming the basis of the Agency's input to this process. The key messages for the Agency's official input to the government's energy review are also being taken from the energy vision. It is exciting to think that my work may be inputting to something as massively important as this.

8.5 Impact Upon my Personal and Professional Development

I feel that I have substantially developed both personally and professionally over the past two years. The process of researching and authoring the sustainable energy vision document has developed my analytical and report writing skills. My technical understanding of energy technologies and systems has increased significantly and my ability to assimilate and condense complex information has grown. In producing the vision I covered a vast range of issues and managed to master and juggle this material, and condense it into a coherent whole. The document could be described as a success in "joined up thinking," and since this is one of the key ingredients for delivering sustainable development I am delighted to have made a worthy attempt. As well as developing these transferable skills, my project work has also progressed my understanding of key sustainable development principles which will help inform my future career (these are explored in section 7.1.1).

The aspects of my project work that have dealt with promoting the need for an Agency energy position, and my general interaction with Agency staff, have also progressed my interpersonal skills and my ability to work with others to resolve complex policy issues. I have undertaken high level discussions with senior managers and energy experts, and my self-confidence in sustainable energy policy has grown (as has my general self-confidence as a professional – and in my professional area). The challenging nature of my project work and the need to confront difficult issues has particularly helped in taking forward my professional competence in sustainability policy making and my interactions with the policy development community. I have learnt much about the process of instigating organisational changes for sustainability, and the methods for exploring sustainability ideas and decision-making. It has been fascinating to observe (and participate in) the process of organisational change, and the many individual

decisions and activities over the past few years that have delivered this change. I have gained invaluable insight into what has helped, and what has hindered, this change process and will take these lessons forward into my future experiences of delivering change for sustainable development.

9 CONCLUSIONS ON MY PROJECT WORK

9.1 Contributing to a Process of Change

My project work has sought to develop the Environment Agency's contribution to sustainable energy. My main project aims have been to develop a long-term vision of sustainable energy for the Environment Agency and to encourage the Agency to adopt an advocacy position on sustainable energy. Overall, I am extremely pleased with the progress towards delivering these project aims. Over the period of my project activity there have been significant developments in the Agency which have improved its capacity to undertake policy advocacy on sustainable energy and to contribute to sustainable energy in general.

I have very much enjoyed implementing my project activities, and thereby contributing to this process of change, and in undertaking a significant role in shaping the Agency's understanding of sustainable energy and of how it can improve its contribution to sustainable energy. Nevertheless, I have faced many challenges when undertaking this project because it has sought to contribute to the process of change in the organisation as a whole. As a result my work in the Sustainable Development Unit has been tied up within large complex organisational issues, and in many ways I have been a small cog in a very large wheel. The change process within the Agency will continue to move forward, and the organisation will face many challenges in its bid to realise the many objectives in its Environmental Vision. Nevertheless, I believe that it is beginning to obtain a better understanding of what it actually means to show leadership in sustainable development.

The Agency is now firmly committed to policy advocacy as a means of increasing its contribution to sustainable development, and is putting in place the capacity for acting as a policy advocate. However, the organisation has still failed to address a key aspect of the process involved in developing sustainability messages for advocacy. Many facets of the sustainability debate are controversial, and these areas of disagreement will be just as much a problem in the Environment Agency as anywhere else. This crucial issue is not being recognised or addressed by the Agency's senior managers, and at this stage I am not sure how the Agency intends to

develop its opinion on the more complex and contentious issues – such contentious issues go to the heart of the sustainable energy debate.

9.2 A Vision of Sustainable Energy for the Environment Agency

My research lead me to determine that developing an energy vision would constitute the best approach for resolving the differences of opinion on sustainable energy in the Agency and to take forward the development of an energy position. The completed sustainable energy vision has had a large and successful impact upon the organisation's thinking on sustainable energy. The Agency's Chairman has outlined his desire for the energy vision to be further developed into an official Agency energy vision, which would form part of an Agency document setting out the organisation's position and policy recommendations for delivering sustainable energy.

The positive response of the UK sustainable energy community has persuaded me that the sustainable energy vision document is a creative and inspiring piece of work that has filled a vacuum in the Agency, and also, to some degree, in the energy policy community at large.

However, I am still unsure how the Agency intends to resolve differences of opinion in order to come to a final position on sustainable energy, and in particular the question of whether there is a future role for nuclear power in a carbon dioxide reduction strategy. As it is the first comprehensive and thoroughly thought-through contribution to the Agency's internal energy debate, the energy vision has successfully grabbed the organisation's attention and the senior managers intend to use it as the foundation for the Agency's eventual energy position. I am hopeful that the messages and ideas in the energy vision will heavily influence the development of the Agency's official energy position over the coming years so that it is based upon energy productivity improvements and renewable energy – which I believe are the key components of a truly sustainable energy system.

9.3 Recommendations For Taking Forward the Sustainable Energy Vision and the Agency's Contribution to Sustainable Energy

- I recommend that the Agency follows the Chairman's wishes and develops the energy vision into an official Agency document. This official Agency energy position document should contain an holistic energy vision (along the lines of the italic section of my vision document – see Appendix 1) followed by policy recommendations for delivering the sustainable energy vision. The Agency could then use this document as a strong underpinning to its energy policy advocacy positions. It is clear, from the comments and response of the external energy policy community, that an energy vision is a very powerful and valuable contribution to the sustainable energy policy debate. Based upon this evidence, I think that the Agency would be wasting an opportunity if they failed to take forward the energy vision – by further improving it and developing it into an Agency official document.

- The Agency also needs to establish an internal decision-making structure for effectively considering complex sustainability issues, such as sustainable energy. The establishment of a cross-functional high level specialist subject group could be the best way of managing this, such as an energy task force to consider the main stance of the Agency's energy policy position.

- The Agency needs to prioritise how it intends to contribute to sustainable energy practices in England and Wales. Once the organisation has developed its energy position, it can prioritise those areas of sustainable energy where it can work collaboratively to make a difference. It could base this prioritisation on those issues which it considers to be the most important and those to which it is most able to contribute. There are potentially a large range of areas on which the Agency could focus, including different aspects of energy efficiency (in which sector?), combined heat and power (for business, public or domestic?) and renewable energy (which technology and what form of support?). The Agency will be unable to take forward its collaborative work in contributing to particular forms of sustainable energy practice until it has prioritised in what areas it

wishes to work, and then developed a strategy which practically outlines what and how it intends to do.

- The Agency should appoint a sustainable energy czar to raise the profile and priority of sustainable energy in the organisation, and thereby enable these initiatives to move forward. This would need to be a senior member of staff, such as a Director, and he/she would need to aim for performance targets so that they stay focused on their czar duties.

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APPENDIX 1

A SUSTAINABLE ENERGY VISION FOR THE UK

A DOCUMENT TO STIMULATE DISCUSSION ABOUT THE COMPOSITION OF A FUTURE LOW CARBON SUSTAINABLE ENERGY SYSTEM

A VISION OF A HIGH-PERFORMANCE ENERGY SYSTEM BASED UPON RENEWABLE ENERGY SOURCES AND A SUBSTANTIALLY REDUCED FOSSIL FUEL INPUT

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1 STIMULATING DISCUSSION ABOUT THE COMPOSITION OF A SUSTAINABLE ENERGY SYSTEM

This vision of sustainable energy for the UK is the output of a research project in the Environment Agency which aims to stimulate and inform the Agency's discussions on sustainable energy, and to begin the process of developing a shared vision of a low-carbon energy system. The energy vision presented consists of the personal opinion and arguments of the author and is not intended to represent the Agency's view.

In January 2001 the Agency published its strategy for contributing to sustainable development, "An Environmental Vision – The Environment Agency's Contribution to Sustainable Development".[27] The Environmental Vision outlines a new environmental outcome focused approach for the Agency and the organisation's intentions to work collaboratively with partners to contribute to balanced and holistic environmental protection and the delivery of sustainable development. The Environmental Vision acknowledges that the attainment of sustainable energy will be a fundamental component of sustainable development, and of addressing climate change.

The Environment Agency is keen to strategically develop its contribution to sustainable energy practices in the UK. This sustainable energy vision has been produced with the aim of contributing to the organisation's new visionary approach by progressing understanding of sustainable energy and helping develop a shared vision of the long-term goal for a UK energy transition. The Agency is keen to involve others in this dialogue and to progress the development of a shared vision of sustainable energy in the UK.

[27] An Environmental Vision – The Environment Agency's Contribution to Sustainable Development, January 2001

2 THE NEED FOR A SUSTAINABLE ENERGY VISION

2.1 A Vision of Sustainable Energy

This document presents a 2050 vision of a sustainable energy system for the UK. The vision is based upon the potential for technological and institutional change in the UK energy system and an assessment of the environmental and economic implications of alternative energy technologies and energy systems. Realising the vision would enable the UK to achieve the long-term substantial greenhouse gas emission reductions that are advocated by the Intergovernmental Panel on Climate Change (IPCC) whilst also adequately satisfying society's energy service requirements.

2.2 The Need for an Energy Transition

The use of fossil fuels in the provision of energy is a primary cause of many environmental problems facing the UK and the rest of the world. The combustion of fossil fuels is both the primary source of local air pollutants such as NO_x, SO_X and particulates, and also of the global atmosphere pollutant, CO_2. In addition, fossil fuels are a finite resource whose availability will decline over the coming century if current rates of consumption continue (and continue to increase). Approximately three-quarters of the UK's greenhouse gas emissions result from the combustion of fossil fuels for energy[28]. For the UK to reduce its greenhouse gas emissions to the levels recommended by the IPCC[29] will require a transition to a carbon-limited energy system during this century which will in turn require profound changes in the way we produce and consume energy. We should not underestimate the importance of undertaking this energy transition, nor the scale and profundity of the changes that will be needed. For these reasons, achieving sustainable energy will be one of the key challenges in the pursuit of a sustainable way of life. In its recent energy study, the Royal Commission on Environmental Pollution supports the IPCC's

[28] (DoE, 1997) *Climate Change – The UK Programme*, HMSO, London

[29] The Intergovernmental Panel on Climate Change (IPCC) recommends a 60 – 80% reduction on 1990's level for greenhouse gas emissions from industrialised countries over the course of this century in order to ensure avoidance of potentially dangerous perturbation of the global atmosphere, (IPCC 1995) *The Science of Climate Change – Summary for Policy Makers*

recommendations and endorses a long-term goal to reduce UK fossil fuel use by 60 – 80% over the course of this century[30]. This is the urgent challenge that faces us.

The opportunities for reducing fossil fuel use are substantial and the UK needs to take advantage of these so that it establishes long-term carbon dioxide emission reductions and puts British business at the forefront of the industrial opportunities of the low-carbon economy.

2.3 UK Leadership in Sustainable Energy - Providing Direction for Energy Policy

In its recent energy report, the Royal Commission on Environmental Pollution argued that the UK is simply not doing enough to grasp such industrial opportunities and steer the UK towards a low carbon society. It also pointed out that although a successful response to climate change will require efforts to reduce emissions by all countries, developed world countries like the UK need to show leadership in reducing emissions, "If the UK cannot demonstrate that it is serious about doing its part to address this threat, it cannot expect other nations – least of all those which are much less wealthy – to do theirs[31]".

The UK does not have a clear long-term direction for its energy policy. Although the UK is committed to greenhouse gas emission reductions and has set very challenging targets[32], these specific policy goals are not couched within a wider coherent policy framework that aims to strategically move the country towards a sustainable energy future. The UK needs a vision of sustainable energy which would provide direction for individual energy policy measures and for guiding long-term investments in the energy market-place. It would also aid public understanding and acceptance of individual policy measures – which would not be seen in isolation, as is presently the case, but as part of a coherent package of measures to transform the UK energy system and deliver carbon dioxide emission reductions.

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[30] *Energy – The Changing Climate,* the twenty-second report of the Royal Commission on Environmental Pollution. June 2000

[31] Paragraph 10.85, page 198, *Energy – The Changing Climate,* the twenty-second report of the Royal Commission on Environmental Pollution. June 2000.

[32] In addition to the Kyoto target, he Government aims for a 20% reduction on 1990s carbon dioxide emissions by 2010, and has a target for 10% of electricity to be provided by renewables by 2010 and 10 gigawatts of electricity to be produced by combined heat and power by 2010

Addressing climate change in the long-term will require nothing less than an energy transition over the next half century or so. This will require substantial changes in the way we produce, transport and consume energy, but as yet society has failed to grasp the scale and fundamental nature of these changes.

Addressing the "energy sector" is so difficult because of the complexity of our energy systems, and the fact that they pervade every aspect of our economy and society. In order to influence energy practices we need to effect policy change in a huge number of sectors, such as industry, agriculture, housing and transport. There is no government department or body that deals with all these different aspects of energy, or that approaches energy at the overall system level, and this makes it difficult for the UK to move along a coherent pathway towards sustainable energy. This failure to take an holistic approach to energy has been identified by Green Alliance in their report, "The Case for a Sustainable Energy Agency"[33].

In the face of climate change and the sheer unsustainability of our present energy system, the UK needs to boldly decide upon a course of action and follow it. Many options are available for reducing fuel and electricity use and for increasing renewable energy output. The Government needs to show greater leadership in directing an energy transition and demonstrating political will and decisive policy making. The energy vision presented in this document attempts to confront this lack of direction and promote a clear path for our energy system. The UK needs to boldly embrace change and to confront the accompanying uncertainties and unknowns. The longer the transition is deferred, the more painful the consequences will be.

2.4 Approaching Energy Use at the System Level

Achieving sustainable energy will require more than simply changing the energy sources of our energy system; it will require a total change in the way the overall system operates[34]. Approaching energy use at the overall system level enables us to

[33] Green Alliance, 1999, *The Case for a Sustainable Energy Agency*
[34] See Glossary for a description of the many components comprising our energy system.

identify the vast array of opportunities for improving the productivity of our energy use.

Although some of the ways we manipulate energy are extremely subtle and technologically advanced, such as electricity use in computers (although much of our hardware still consumes far more electricity than is technically necessary), other ways are extremely primitive. Probably our crudest management of energy is our manipulation of heat in buildings. Although one of the main purposes of a building is to create and maintain a comfortable living temperature for the occupants, we have failed to apply our technological know-how in constructing buildings that subtly control heat balances. As a result we unnecessarily waste huge quantities of energy by pumping heat into thermally inefficient structures which is almost instantly lost to the outside atmosphere. Great opportunities are available for managing heat balances more subtly in our building stock but, due to externalities and distortions in the market-place[35], these opportunities are hardly being exploited at all.

This one example of a highly unproductive and wasteful use of energy serves to illustrate that an assessment of sustainable energy requires far more than a simplistic evaluation of the quantities of fuels and alternative energy sources that are available. In directing the energy transition we need to grasp the opportunities for changing the entire way we deliver energy services. No part of our energy system is fixed. Over long time horizons we can change every aspect of our energy infrastructure ranging from the structure of the electricity distribution system to the efficiency of electrical appliances. Through improving the subtlety of the delivery of our energy services we can change the demands on our energy inputs.

2.5 A Visionary Approach to Sustainable Energy

A visionary approach to sustainable energy is vital in order to identify the many opportunities for change that already abound in energy technologies, institutions and society in general. In addition, setting challenging aspirational targets can help direct the process of sustainable development. A visionary approach can identify solutions which go beyond the constraints of the present-day to envisage how things could be

[35] For a description of externalities and market distortions see Glossary.

done differently in the future. In the consideration of sustainable energy a visionary approach is particularly necessary because of the scale and complexities of our energy system[36], the many varied drivers that influence it and the need to manage so many uncertainties and unknowns in the analysis. Tomorrow's technologies, infrastructure, market-place and institutional arrangements need not be the same as today's (in fact they are very unlikely to be the same). In considering the future of our energy system we need to bear in mind the processes of economic, technological and societal evolution that will take place over the coming decades, and resist the temptation to view industrial change (structural economic change) as having a negative economic impact. The world of fifty years ago was tremendously different to the world of today and we could not possibly have predicted the technological, economic and cultural changes that have occurred. The same is likely of the next fifty years. We must also consider the vast number of changes that will be required in all other aspects of our economy in order to achieve sustainable development, and the implications this will have for the way that we use energy.

[36] To convey how complete the penetration of energy use and manipulation is within our society Walt Patterson refers to our energy system as "the entire energy infrastructure of society".

3 A VISION OF SUSTAINABLE ENERGY FOR THE UK

3.1 Introduction to the Vision

What will the UK's energy system look like in the future? What would we like it to look like? If we are to direct our energy system towards sustainability then what is our vision of sustainable energy?

The energy vision presented in this document has a time horizon of fifty years which allows sufficient time for significant technological and institutional developments and changes to occur, whilst also keeping this mental exercise within manageable time scales. The intention of this vision is to illuminate what is possible and desirable, and thereby give shape to the enormous potential that already exists technologically, institutionally and professionally. The majority of the technologies (or technological changes) upon which this vision is based are already available to the market place, or could be brought about through further development and investment over the coming decades. The vision demonstrates how existing (or developing) technologies, and economic and societal change, could come together to create a sustainable energy system.

Although most analyses tend to break down fuel and electricity use by economic sector, it is more illuminating to consider the three main energy demands in the UK. Electricity generation, heating for buildings (and hot water), and transport are currently responsible for consuming approximately a third each of UK primary energy use. High-grade heat for industrial processes represents a much smaller burden on overall energy use at approximately eight per cent. This vision concentrates on society's production and use of electricity and heat, and on transport energy use. It does not cover industrial demand for high-grade heat due to the very specific nature of industrial high-grade heat consumption. Nevertheless, there are numerous opportunities for reducing fuel use for industrial heating activities. This could be achieved through efficiency improvements in industrial processes, improved recycling of metals and plastics and a reduced societal consumption of energy intensive chemicals and materials. All these developments could be brought about by incentivising industrial behaviour through increasing fuel prices.

3.2 THE VISION – AN OVERVIEW

It is 2050 and the UK has a radically different energy system to the one which characterised the 20th century. The UK has achieved a highly efficient energy system powered by renewable energy sources and substantially reduced fossil fuel inputs which delivers the many high quality energy services required by modern society. The manipulation of energy in all applications across all sectors is highly subtle and sophisticated. The high energy conversion efficiency of fuel cells, and their capacity to deliver electrical, heat and transport services, means that they play a central role in this 2050 energy system. Along with the development of decentralised electricity generation, they have driven a convergence of the electricity, heat and transport systems, and are beginning to enable renewably generated energy to efficiently provide for our heat and transport requirements as well as electrical services. As a result the UK is now on the brink of realising a full hydrogen economy, and a complete solution for the total replacement of fossil fuels in our energy system. Decentralised electricity generation has delivered huge fuel productivity benefits by enabling heat and power to converge, and it has enabled the massive growth in renewable energy exploitation.

In this 2050 energy system the traditional "energy supply" and "energy demand" aspects of energy service delivery have been merged due to large amounts of on-site electricity generation and local electricity and biomass production. Energy services are therefore managed at the local (on-site) level which focuses management attention on the efficiency and performance of fuel and electricity use, rather than the quantity of fuel supplied. High quality energy services are provided by optimising the energy conversion technology and end-use hardware. All energy services are delivered through the combination of fuel or electricity, and end use hardware – in the case of warmth provision, for example, the energy hardware consists of both the gas boiler and central heating system (energy conversion and distribution technology), and the building itself. Through widespread improvements in the performance and effectiveness of energy hardware the quality, or quantity, of energy services have been improved whilst the quantity of fuel or electricity consumed has declined.

As part of the general drive towards sustainability, dematerialisation of the UK economy has been progressing well during the twenty-first century and it is now far less materials and energy intensive. The new service oriented economy focuses on service provision rather than continuously increasing the production and supply of material goods. This has reduced waste, increased product lifespan and reduced the quantity of materials flowing through the UK economy – which in turn has reduced the amount of embodied energy which is consumed in the manufacture and transport of these materials and waste. Energy use and economic growth have been decoupled because the basis of economic growth has shifted over the last fifty years from the old unsustainable industries of previous centuries to the modern hi-tech environmental industries. Energy Service Companies provide all energy services to domestic and commercial customers. They manage and control all electricity and heat production and purchasing, and the efficiency of energy use, so that energy efficiency is maximised.

The market-place, and governance and institutional structures, of the 2050 energy system have changed and developed substantially since the 20th century. The roll-out of environmental tax reform over the course of the 21st century has shifted the tax burden off human labour and onto the use of resources and energy. This fiscal reform has been instrumental in delivering the dematerialised service-oriented economy. The carbon tax was progressively raised throughout the early years of the century which, along with other targeted measures, drove the massive energy efficiency gains in the economy and the development of the decentralised electricity system and the expansion of renewable energy. These market changes delivered a market-place focused on developing and disseminating efficient technologies and management techniques. A whole raft of legislative measures prioritised energy efficiency in heating, and in electricity appliances and generation, and energy management in business. These legislative changes delivered an institutional and governance structure that focused on energy management and efficiency. Through focusing on developing the technological and institutional potential for improving energy manipulation and the exploitation of renewable energy society has succeeded in delivering a highly energy efficient renewably powered economy. The entire policy framework for delivering sustainable energy has been coordinated and overseen by the Sustainable Energy Agency which was established early in the 21st

century to provide clearer direction for government policy, and to ensure synergy and coherence between the different arms of government responsible for different aspects of energy policy. The UK has progressively achieved its greenhouse gas emission reduction targets over the course of the century. It has reduced fossil fuel use and carbon dioxide emissions by 75% and has led the way in the industrial response to climate change. This has created a competitive edge for UK business and has contributed to the prosperity of the British economy.

The UK economy in 2050 requires approximately half the primary energy input (fossil fuels and renewables) than in 2001 because it is highly productive in the way it generates and uses electricity and heat, and in its use of fuel for transport. It uses approximately a quarter of the quantity of fossil fuels, with fossil fuels and renewable energy delivering about 50% each of the primary energy input. The quantity of energy harnessed from renewable energy flows has increased by ten to fifteen fold. The widespread use of combined heat and power, and extensive renewable energy exploitation, means that electricity generation no longer exerts a separate demand on fossil fuel supplies in the same way as the centralised electricity system of the 20th century. Electricity consumption has reduced by over 50% through efficiency gains in electrical appliances. Although coal is no longer in use due to its high carbon dioxide emissions,[37] petroleum and natural gas still play an important role (directly through combustion and as hydrogen carriers) in transport and heating (CHP plants), particularly for industrial high-grade heat. The quantity of oil and gas required for transport and heating has reduced by almost two-thirds due to efficiency gains in buildings and vehicles, and the use of biomass for heating. Transport fuel demand has reduced by 85% due to the use of highly fuel efficient vehicles, a greater shift to public transport and a general reduced demand for transport.[38]

The main drivers for this reduction in fuel and electricity demand are:

[37] In addition to the lower efficiency of conventional steam turbines compared to CCGT in electricity generation, coal produces almost twice the amount of carbon dioxide per unit of energy as does natural gas.

[38] See the relevant sections in the vision for details of these energy productivity improvements.

- *the development of Energy Service Companies which deliver the entire energy service to customers, rather than just the fuel, and are engaged in improving the efficiency of their customers' buildings and appliances;*
- *the general dematerialisation of economic activity and the development of a "service economy" which concentrates on the service provided rather than the material throughput of the economy. The reduced wastage in the economy has the knock-on effect of reducing the amount of "embodied energy" which was originally contained within these wasted materials;*
- *the substantial reduction in the quantity of fuel required to heat buildings due to improvements in the thermal efficiency of the building stock, and increased use of passive solar energy through improved design;*
- *the development of a decentralised electricity system and across the board adoption of combined heat and power (both macro and micro) leading to massive fuel efficiency gains and a reduction in transmission losses;*
- *a reduction in the quantity of electricity consumed due to efficiency improvements in all electrical appliances and across the board adoption of fluorescent lighting, and the use of microelectronics to better manage load at individual site level and across localities;*
- *the penetration of fuel cells as the main energy conversion technology which has substantially improved the efficiency of fuel use and electricity generation;*
- *a massive increase in renewable energy use including onshore and offshore, and micro (individual site level) renewables; and,*
- *the penetration of highly efficient hypercars and a reduced dependence on private car use.*

In summary, the overall demand for fuels and electricity has been reduced through:

- *improved efficiency of end-use hardware, and reduced demand for energy resulting from economic and societal changes (SUSTAINABLE ENERGY USE); and*
- *higher conversion efficiency and lower transmission losses in electricity and heat generation, and highly efficient vehicles, and increased use of renewable energy (SUSTAINABLE ENERGY PROVISION).*

The more detailed presentation of the vision is divided into these two main components of sustainable energy use and sustainable energy provision.

3.3 SUSTAINABLE ENERGY USE – A REDUCED DEMAND FOR FUELS AND ELECTRICITY

3.3.1 Introduction

The improved efficiency with which we use fuels and electricity (at the end-user stage) is the most fundamental component of this energy vision. UK markets and institutions recognise the environmental and economic value of energy and the costs of wasteful energy use. All energy using hardware in 2050 is extremely sophisticated in its use and management of energy. Sustainable energy use is composed of five main elements:

- *A vastly more efficient UK building stock;*
- *Complete penetration of highly efficient electrical devices;*
- *Sophisticated IT control of heat and electricity use in business and in homes;*
- *Progression towards a dematerialised economy; and*
- *Highly efficient vehicles and a slightly reduced demand for private vehicle use and mobility in general.*

3.3.2 Improved Heat Management in UK Buildings

UK society has reduced its demand for heating fuels whilst also improving the thermal comfort of its buildings. Large quantities of fuel-generated heat are no longer required to maintain a comfortable temperature in buildings. This substantially improved efficiency level has enabled the UK to slash its overall demand for fuel – as heating represented the single largest energy demand in the year 2000. Gone are the days when the UK had one of the most inefficient building stocks in Europe[39]. UK buildings in 2050 require approximately 40 to 50 of the external heating input of that required in 2000. Ultra energy efficient buildings constitute twenty-five percent of the UK stock, and these require just 10% of the heating requirements of an average building in the year 2000[40]. 75% of the building stock consists of pre-21st Century buildings. These have been substantially up-

[39] See Appendix 2 for details of the inefficiency of UK buildings.

graded and improved so that they require approximately 60% of their original heating needs[41].

3.3.3 Ultra Energy Efficient New Buildings

Since the early part of the 21st Century ultra energy efficient buildings have been constructed in the UK. These require only a tenth of the heat input that is required by the average British building in the 20th Century[42]*. Ultra-efficient houses have been built as standard since early in the twenty-first century, and now constitute 25% of the building stock. These houses feature a range of improvements on the conventional buildings constructed pre-2000. They benefit from substantial passive solar energy heating supplied from all-glass south facing walls, and by capturing the body heat and cooking and electrical heat from the occupants. The buildings are effective at storing and re-radiating the day's warmth through the evening and night due to their large thermal mass and high levels of insulation. The buildings are well insulated and sealed, and ventilation is provided via special ducts with heat exchangers. Solar water heating is a standard feature in all these buildings.*

Government legislation (targeted through the Building Regulations) in the early 21st Century established a timetable outlining mandatory improvements in the efficiency standards for new UK homes. This ensured that by 2025 all new homes would achieve ultra energy efficient standards – with a quick progression in the efficiency standards in new buildings over the twenty-five years until then. This gave the house-builders enough time to develop industry wide large-scale building techniques for constructing these ultra efficient houses.

More efficient boilers, combined heat and power units, heat pumps and community heating schemes have also improved the efficiency of fuel use (both fossil fuels and biomass) in heating – this is dealt with below.

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[40] See the description of the BedZED scheme in section 6.6

[41] A number of studies illustrate that UK building energy use could be reduced by a third through cost-effective efficiency improvements – see footnote 21 below – further improvements have been achieved in this vision through extensive government efficiency programmes taking improvements beyond the cost-effective mark.

[42] See the description of the BedZED scheme in section 6.6

All commercial buildings constructed since the beginning of this century have also been designed to maximise the levels of natural lighting and to benefit from passive solar heating. Not only has this substantially reduced the need for (and levels of) artificial light but it has also resulted in significant health benefits for office workers and delivered a better working environment with staff productivity gains. These highly efficient office buildings require less than 50% of the fuel needs of 20th century offices for heating, cooling and lighting due to natural ventilation systems removing the need for air conditioning and passive solar heating serving the majority of the buildings heating needs.[43] *Further electricity reductions have been enabled through more efficient office equipment.*[44]

3.3.4 Improved Energy Performance of Pre-21st Century Buildings

A rigorous programme of energy efficiency improvements in UK homes has enabled the efficiency of the pre-21st Century building stock to improve by 40%. The energy efficiency of buildings with cavity walls have been improved by 50%, through cavity wall and loft insulation, and extensive efficiency retrofitting beyond the cost-effective improvements (even with higher fuel prices). Solid walled buildings are not able to achieve quite as high a level of efficiency but nevertheless the complete adoption of extensive energy efficiency measures has delivered fuel savings of up to 40%. The increased attention allocated to the efficiency of buildings has brought with it financial help from the Government for home-owners to increase the efficiency of their buildings beyond the 30% cost effective efficiency improvements[45] *to obtain a further 10 to 20% efficiency improvement. A number of other policy measures and the development of Energy Service Companies have enabled the uptake of cost-effective efficiency improvements. Grants for these further improvements have had a great deal of success over the years in improving the efficiency of the building stock still further.*

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[43] See the description of The Queen's Building , De Montfort University in section 6.6.

[44] See section 3.4.8 and Appendix 2.

[45] A number of studies illustrate that energy use could be reduced by a third through cost-effective efficiency improvements – see Association for Energy Conservation (ACE) 1997 *A Realistic Strategy for Reducing Greenhouse Gas Emissions in the Period 2000-2010 using Improvements in Energy End-Use Efficiency*;
Energy Saving Trust (EST) 1997, *Energy Efficiency and Environmental Benefits to 2010;* and,
Shorrock, L. D 1995, *Potential Carbon Savings from Energy Efficiency in Housing,* BRE Information Paper.

There are seven main ways in which the efficiency of buildings has been improved:

- *Solid wall insulation*
- *Cavity wall insulation*
- *Loft insulation*
- *Double glazing*
- *Installation of low emissivity glass*
- *Efficient new boilers, CHP and heat pumps*
- *Passive use of solar energy*

The above measures have been implemented in all existing buildings and a substantial proportion have undertaken significant retrofitting so as to benefit from passive solar heating and better heat retention.

There have been a number of legislative and market changes that have brought about this vast improvement in the efficiency of the building stock. Initially government support for energy efficiency improvements, mainly through an enlarged Energy Efficiency Commitment (formerly the Energy efficiency Standards of Performance) on energy utilities, ensured that far greater resources were allocated towards improving the energy efficiency of houses. This early momentum was then built upon through the evolution of Energy Service Companies over the first twenty years of this century. The re-orientation of the energy market towards service delivery has been the main driver for the vast improvements in the energy efficiency of UK buildings (see below for description and explanation of ESCos). Other drivers have included requirements on fuel and electricity suppliers to have regard for the efficiency of fuel use by their customers, the increasing price of fuel which has reduced the economic payback time for efficiency improvements, local government grants for efficiency improvement work and general legislative changes to the "heating" market place so that customers paid for warmth rather the fuel consumed (see below). As mentioned above the government has also provided capital grants encouraging building owners who have already undertaken cost-effective efficiency measures to undertake further improvements.

As the price of fuels and electricity increased, and the profile of energy efficiency heightened, the energy performance of houses began to feature in their price. Energy

efficiency information became a core component of the house market and accurate information was provided about the energy consumption of buildings. As energy efficiency improvements added value to buildings, owners had a greater incentive to invest in efficiency improvements – even those with a long payback time. The bills charged by Energy Service Companies are significantly higher for inefficient buildings which has further increased the market value of energy efficient houses. As efficiency is now a significant feature of the desirability and value of a property, landlords also take an interest in improving their properties so that they remain competitive on the rental market and their value is not affected when they come to sell them. Tenants are not prepared to pay very high heating bills or to subsidise efficiency improvements on their landlord's behalf through their ESCo bill.

More efficient boilers and combined heat and power units, and community heating schemes, have also improved the efficiency of fuel use (both fossil fuels and biomass) in heating – and this is dealt with in more detail below.

3.3.5 Fuel Poverty No Longer Exists

There is no fuel poverty in this vision because UK homes are far more efficient – the chronically energy inefficient houses which were the primary cause of fuel poverty have all been replaced by new energy efficient buildings. Lower income groups now occupy homes attaining the same efficiency levels as private sector housing and they therefore require far less fuel in order to maintain a comfortable temperature. The improvements in the social housing stock have been brought about through increased social spending as well as by the market place changes to deliver full energy services and the government energy efficiency legislation which brought about the corresponding improvements in the private housing stock.

3.3.6 Widespread Use of Heat Pumps[46]

Heat pumps represent a highly efficient way of generating heat from electricity – they deliver two to four times the amount of heat energy than they consume in electrical energy. The electric heating methods of the 20th century provided a third of the quantity of heat for the amount of electricity used than do heat pumps. Heat

[46] For technical description of heat pump see the Glossary

pumps play a valuable role in supplementing the heating requirements of buildings. They provide the back-up for the heating supplied by CHP plants and micro-CHP units, and that provided by active and passive solar heating. These heat pumps take the form of individual household heat pumps, and larger community heating scheme heat pumps. Biomass is the only renewable which can directly produce heat. However, heat pumps are an efficient means of converting the electricity produced from the other renewable energy sources into heat for buildings – and this enables further reductions in fossil fuel use.

The electricity required to power these heat pumps is primarily provided by renewable energy sources. On the domestic scale this electricity might come from the PV cells on the roof of the building or from the biomass community CHP plant. Alternatively, the electricity might be that from a large offshore wind farm. Electricity from all these sources surges down the power lines of the local distribution network (see next section). In ultra energy efficient buildings the demand for heat input is fairly small, and it is often more cost-effective to simply generate electricity rather than heat as well. In these circumstances the electricity from a fuel cell or from a renewable source is used to power a heat pump to provide the necessary heat input to the building. This has become a particularly common feature of the ultra efficient new buildings constructed over the last twenty years or so. The flexibility provided by heat pumps is also effective in managing the seasonality of the demand for heat. Whereas the heat output of CHP plants is less important in the summer months (although it can be used for cooling) electricity can be diverted to heat pumps as and when they are needed.

3.3.7 The Development of Energy Service Companies (ESCo)[47]

All energy services are provided by Energy Service Companies (ESCos) which provide and manage much of the energy hardware as well as the fuel and electricity supplying them. A combination of legislative changes to the electricity and gas markets, increased fuel price, reduced labour costs (due to a shift in the tax burden – see eco-taxation in the Dematerialisation section below) and legislative

[47] The Energy Saving Trust is currently running an *Energy Services Programme* which includes research, feasibility studies and pilot projects stimulating energy services for the business and domestic sectors.

requirements on energy utilities to have responsibility for the efficiency of electrical appliances and the energy efficiency standards of buildings have resulted in all energy utilities evolving into ESCos. Thus, domestic and commercial customers are now paying energy companies to deliver and manage their energy services rather than just their fuel and electricity. This has spawned a huge growth in the energy management industry and generated substantial employment benefits. It has also successfully reduced fuel and electricity use by transferring the market competition onto the quality of the energy service provided rather than simply the price of the fuel. The increased competition in the liberalised market has also been responsible for encouraging the development of ESCos as companies have struggled to differentiate themselves. Legislative change in the electricity and gas markets enabled energy utilities to establish long-term contracts with commercial and domestic customers to provide their energy services.

Customers pay ESCos to deliver their energy services. For the domestic customer this includes, for example, keeping their home warm, lighting their house and providing food refrigeration. The ESCos have the incentive to ensure that the building is well insulated because in the long-run that will save both them and the home-owner money – the customer can pay a set-fee for these services over a long-term period so that the costs of the insulation are spread out. The ESCo owns the electrical appliances in the building and leases their services to the customer. It is in the interest of the ESCo to ensure that the appliances are operating at as high an efficiency as possible and that the appliances are repaired or recycled at their end of life. The ESCo also install and manage the microelectronic control systems that undertake the subtle management of the building's energy generation and consumption patterns, and its interactions with the local electricity distribution network. The ESCo provides a complete and reliable service, such as a 24 hour maintenance call-out service which covers every single aspect of a customer's energy service requirements from the on-site generation equipment to the electrical appliances.

The evolution of energy service delivery provided by ESCos, in place of the old electricity and fuel supply companies, has contributed substantially to the energy efficiency improvements in buildings. This in turn has contributed to the reductions

in fuel and electricity use for heating and electrical services. The energy efficiency of houses is an important determinant of their price and so the efficiency investments undertaken by the ESCo will always bring a net gain for the customer even if they should move on before they have had much time to benefit from the improved comfort of the property.

3.3.8 Highly Efficient Electrical Goods

Efficiency improvements, coupled with sophisticated electricity management techniques, has enabled electricity consumption to reduce by over a half even though the amount of microelectronic equipment has continued to grow throughout the century[48]*. Overall the efficiency of lighting, computers, televisions, refrigerators and all other electrical appliances has increased to three times its level at the beginning of the century. Some appliances, such as fridge-freezers, require only a quarter of the electricity they consumed in the 20th century. Fluorescent lighting has entirely taken over from incandescent lighting*[49] *which, coupled with more responsible lighting management (i.e. remote sensors and timers turn off lights when they are not needed) and extensive use of natural lighting in offices, has reduced electricity demand for lighting by approximately a half*[50]*. The energy efficient offices built since the turn of the century take maximum advantage of natural sunlight and therefore have just 50 to 25% of the lighting requirements of older offices.*[51]

As is outlined below, televisions and stereos are now fitted with a timed "stand-by" mode, or lack the function altogether, due to the wasteful use of electricity that the standby function encouraged. This is the case even though appliances in this mode became far more efficient over the first twenty years of the century as the manufacturers responsible sought to remove this poor environmental performance from their products. On top of this, once energy utilities began to compete on the

[48] See Appendix 2 for details of energy efficient electrical appliances.
[49] Compact fluorescent lighting consumes approximately a quarter of the electricity of incandescent lighting but in the domestic sector incandescent lighting consumes 85% of lighting–related electricity (data from the Market Transformation Programme website).
[50] Lighting consumes almost a quarter of UK electricity. Business is a far bigger consumer of lighting than the domestic sector and fluorescent lighting is already fairly well installed – however, further use of fluorescent lighting and better management could reduce electricity use by a third (from the Market Transformation Programme website).
[51] See *Factor Four*, Weizsacker et al.

price of delivering the entire energy service (see ESCos below) they soon sought to reduce any unnecessary wastage and inefficiency from their electrical equipment.

The increased price of electricity in the first few decades of this century (to reflect the environmental externalities of fossil fuel use) and the development of ESCos encouraged the development and installation of energy efficient appliances. The combination of Government policy and regulation changed the incentives in the market-place and committed manufacturers so that energy efficiency became a key feature in the manufacture and purchasing of electrical equipment. These relatively simple measures had a vast impact on electricity consumption in the UK, and contributed substantially to the sustainable energy use presented in this vision. Throughout the 20th Century the centralised production of electricity meant that virtually all policy measures were focused on the supply of electricity and very few measures were targeted at the more difficult to access highly disparate end-users. However, following the liberalisation of the electricity market, and the subsequent development of micropower and decentralised generation, the means of electricity supply became almost as decentralised as electricity consumption such that both the industry and government began to focus on both electricity supply and use as a means of manipulating electricity services.

The scope for reducing electricity use in the domestic and commercial sectors would have been very large even if the most efficient technologies available in the 1980s and 1990s were adopted and efficiency levels remained at the same level from that point onwards.[52] *However, once the market place focused on efficiency improvements then the efficiency of electrical appliances continued to increase which has enabled electricity use to decline by over a half even allowing for growth in electronic equipment and the number of households.*

3.3.9 The Use of Microelectronic Control Systems

All buildings' electricity and heat loads are carefully managed by microelectronic control systems. The application of sophisticated microelectronic control systems to electricity and heating systems was brought about in the early 21st Century by a

[52] See Appendix 2.

combination of factors including the continued development of the microelectronic industry, and a greater focus on sophisticated energy management (brought about through Government legislation, higher fuel and electricity prices in recognition of the environmental externalities associated with fossil fuel use and the presence of ESCos - see above). These ensure that an electricity user's (a commercial or household unit) power needs are being met in the most efficient way possible by balancing the user's production, or purchase of electricity, and their use of electricity. The microelectronic control system also enable electricity consumers to reduce their overall consumption through focusing management attention on redundant appliances at any particular moment in time. The control system visually displays all power consuming appliances in the building and enables the energy manager (or the homeowner) to assess which appliances are not being used at any particular time, and which are a priority at that time. This management can be performed in the building or remotely through the internet.

In the late 20th and very early 21st centuries electricity consumption was growing in the commercial and domestic sectors. However, although much of this growth was due to an increase in the quantity of electronic equipment it became clear that much of this equipment was consuming power when not actually in use, either because it was in stand-by mode or because the appliance was simply left on – and that a growth in the amount of equipment did not necessarily mean that it all needs to be used at the same time[53]. As a means of managing energy services an upper level of electricity consumption at any one time is built into the control system so that unnecessary levels of consumption are not reached. The energy manager (or homeowner or ESCo) is then able to view the appliances consuming electricity and switch-off those that are not in use or a priority. Alternatively certain appliances, such as refrigerators, could be automatically switched-off for short periods when peak levels are reached – this particularly helps to smooth out "peak demand" (see below).

[53] It is already possible to reduce office electricity use by up to 65% through the adoption of energy efficient equipment and good management practices – see Market Transformation Programme supporting material.

Energy managers and ESCos focus on more effectively managing electricity use because in the sophisticated micropower systems of 2050 it is cheaper and more effective to control high consumption levels rather than have extra renewables generating capacity, local or distant to the user, available for uncontrolled peak demand. Thus, the upper consumption level is not forced on domestic and commercial consumers through impractical, draconian means such as detailed legislation outlining the maximum electricity consumption for different categories of user, but is undertaken as general practice by the Energy Service Companies that control and manage the majority of commercial and domestic users energy needs. This enables the most cost-effective management of energy services by allowing the following management techniques:

In the decentralised electricity system "peak load" is managed through focusing on controlling the "demand" for electricity rather than the supply. The majority of the time local electricity networks balance themselves out (see decentralised electricity system below) but when national demand is particularly high (due to a national event such as a football match) peak load is smoothed out through all individual units (domestic and commercial users) having an upper electricity consumption threshold set just above their usual (average) electricity consumption level. This is even the case for commercial users with their own large CHP units – it is still cheaper to control demand than to increase supply if some equipment is consuming electricity whilst not being directly used. The focus on sophisticated energy management (and its growth as an industry) has meant that microelectronic control of electricity use has become extremely subtle and the most cost-effective means of controlling energy services. (Note that stored fuels in the form of hydrogen, biomass and fossil fuels for fuel cell and combustion CHP are also available for enabling a flexible response to changing electricity consumption levels, as are the large offshore renewable energy plants and the balancing effects of all other local distribution networks around the country – see next section for more details).

Microelectronic control systems have helped to control the growth in domestic and commercial electricity consumption by focusing attention on the number of appliances using electricity and those appliances that are not carrying out a useful

function at any point in time. These appliances can then be switched off when not in direct use.

Microelectronic control systems have helped to do away with the energy greedy stand-by mode of many domestic electric appliances which were responsible for consuming electricity whilst providing no benefit for the majority of the time. ESCos have replaced stand-by equipment with more efficient appliances which keep the overall load lower thereby delivering the energy service at a cheaper price – cutting costs for themselves and for the customer.

Buildings with their own microgeneration (such as a CHP unit, PV cells or micro-wind) use electronic control systems to ensure that electricity and heat generation are balanced with demand. The control system balances the power requirements of the building with on site generation and brings in extra capacity from the local distribution network if required.

3.3.10 Dematerialisation

Society has also reduced its demand for fuels and electricity through dematerialisation of the economy. The economy is radically more resource and energy productive and is based upon a closed loop service and flow economic model. The economy has grown substantially but now uses fewer resources than it did – i.e. it delivers more but consumes less due to the removal of wastage from the system[54]*. These productivity gains are based upon significant leaps in design and technology for industrial processes, and the manufacture and provision of goods and services. The opportunities for improving material efficiency have been as vast as those for improving energy efficiency. The improvements in material productivity have delivered a reduction in the quantities of material flowing through our industrial system. This has eliminated the need for energy with which to service and transport this unproductive material. Waste arisings have also substantially reduced which has in turn reduced the quantity of embodied energy found in waste. These*

[54] *Factor Four – Doubling Wealth, Halving Resource Use* by Weizsacker et al provides fifty examples (case studies) whereby resource and energy efficiency has been quadrupled – there is no reason why the efficiency gains demonstrated in these examples could not be multiplied thousands of times over across the economy.

resource productivity gains have provided economic advantages for UK business bringing competitiveness and employment benefits.

Dematerialisation has also come about through a re-orientation of economic practice upon the service and flow model as opposed to the goods and purchase economy. The service economy has developed as an extension of the producer responsibility principle and consists of companies delivering services rather than goods so that they maintain responsibility for the management of their products and for repairing and recycling them. This increases the life-span of durable goods so that waste arisings are reduced, and enables closed-loop manufacturing systems so that all products are recycled – and their initial design takes account of their recyclability. Since the extraction and processing of raw materials tends to be very energy intensive, this greater recycling rate of durable goods has the benefit of significantly reducing industrial energy use. Factor ten productivity improvements have been realised over the last fifty years – often through design and process advances which avoided continuing diminishing returns to efforts to improve resource efficiency because of "whole-system optimisation[55]". Whole system optimisation involves by-passing small incremental steps to undertaking more profound changes which can remove initial barriers and then lead to continuing efficiency improvements. The service economy has also involved growth in the knowledge aspects of our economy, and delivered improvements in our manipulation of resources and delivering the services we require.

The Environmental Tax Reform programme that the Treasury has gradually rolled out over the course of the century has enabled dematerialisation to occur. The tax burden has been shifted from employment and labour and onto material resources. The programme has been specifically targeted on removing the tax from environmental "goods", such as human labour installing insulation materials and levying it on the environmental "bads", such as profligate inefficient energy use.

In the dematerialised economy economic growth is not based on an expansion in the consumption of natural resources, but on growth in the "dematerialising activities"

[55] See *Natural Capitalism* by Hawken et al.

of our economy. The growth in "environmental industries" over the last fifty years has been massive which has benefited the UK economy. The taxation system has encouraged a reduction in the use of material resources and an expansion in the use of skilled labour in the delivery of our services. To name just a few, the energy efficiency industries and recycling industries have all expanded significantly whilst the environmental sectors of all businesses have expanded to reduce the impacts of their activities upon the environment. Therefore, the economic growth of recent years has been in activities that lessen the impact of the economy upon the environment. All of this has improved the fuel and electricity productivity of UK society.

3.3.11 Sustainable Transport

The transport system of 2050 is free from the congestion and social disintegration problems that characterised the uncontrolled expansion of the private car at the turn of the century. Noise and local air pollution have almost been totally eliminated due to the use of silent fuel cells – although the slight hum of electric motors serves to gently alert pedestrians to the presence of moving vehicles. Fossil fuel use has been reduced by 85% due to:

- *Reduced fuel demand of vehicles due to the development of "hypervehicles" which require a sixth of the energy input to power them compared to the average vehicle in 2000;*
- *A slightly reduced need for travel in our everyday lives, and in business, due to the further development and uptake of telecommunication technologies and the internet; and,*
- *the transferral of the majority of travel from private transport to public transport, and short distance journeys undertaken by bicycle and foot.*

3.3.12 Super Energy Efficient Vehicles

The vehicles in use in 2050 are 6 times as energy efficient as those at the turn of the century. This vast efficiency improvement has been brought about through two main features; the replacement of heavy steel bodies with light carbon fibre composite bodies and the use of efficient fuel cell power systems which each improve the

efficiency of the vehicle by 3 fold.[56] *The majority of the energy consumption of steel bodied cars was expended on carrying, and accelerating, the very heavy body of the car. Typically only 1% of the energy in the fuel actually ended up moving the driver forward. The composite bodies of the "hypercars" in use today are a third of the weight of steel cars and therefore require a third of the energy to power them forward.*[57] *The benefits of the lighter shell are compounded because other components in turn require less bulk. The composite material is ultra-strong and therefore provides adequate crash protection for the vehicle occupants – particularly since the lighter vehicles have a reduced weight behind the impact. The energy expended during braking is also captured and recycled back into the electric motor through a regenerative electronic braking system*[58]*. The efficiency benefits of the fuel cell power system are looked at in the Sustainable Energy Production chapter below.*

3.3.13 Reduced Demand For Private And Trade Vehicles, And For Mobility In General

There are significantly fewer vehicles on the road in 2050 than there were at the turn of the century. The amount of travel has fallen slightly over the course of the century and the majority of travel now takes place through the use of public transport and cycling and walking. The reliability and frequency of trams, trains and buses are vastly improved and take priority over private car use. The trams and buses take priority over private cars in urban areas and are therefore able to run smoothly and to timetables. Car sharing is a common feature of car ownership and local journeys are largely undertaken by foot and bicycle. The reduced society investment in private vehicles has enabled increased investment in the public forms of transport. Urban areas are deeply penetrated by separate cycle lane systems which has vastly increased the safety and ease of cycling. Business and freight traffic has also reduced substantially with fewer vans and lorries on the road.

[56] See sections 3.3.5 & 3.3.6 below for information on the fuel cell and its use in vehicles.
[57] See *Factor Four, Weizsacker et al* for information on the hypercar – prototypes have already been developed by the main car manufacturers.
[58] Regenerative electronic braking systems already exist – see section 1.1 *Factor Four, Weizsacker et al*

The digital economy and increased penetration of information technology and telecommunications in our society have had a small impact in reducing the need for travel. Business travel has been reduced through the widespread use of high quality teleconferencing equipment. The amount of work undertaken at home, or near home in tele-working centres, is very large amounting to one day a week averaged out across the entire work-force. The efficiency of the transportation of goods and services has been increased through the application of IT systems to rail and road freight transport so that unnecessary long journeys and the movement of empty carriages has almost been eliminated. The radical resource productivity improvements of the dematerialised economy have contributed to a reduction in the quantity of material and goods being transported, and a corresponding decrease in the quantity of freight and trade transport.

3.3.14 The Development of the Sustainable Transport System

The increased investment in public transport systems and the planning and prioritisation of public transport in urban areas enabled the development of frequent and reliable public transport services. Coupled with increased costs and penalties on car use this halted and even reversed the growth in private car use. The climate change, and other environmental and social, costs associated with car use were gradually introduced into the price using cars with increased fuel costs and road pricing. The transition to fuel cell vehicles was encouraged through differential fuel pricing and the lower costs associated with these more efficient vehicles.

3.4 SUSTAINABLE ELECTRICITY AND HEAT PROVISION – USING FUELS MORE EFFICIENTLY AND UTILISING RENEWABLE ENERGY

3.4.1 Introduction

The way in which the UK generates and distributes electricity and heat has changed markedly so as to substantially reduce the quantity of fuel that is required, and reduce the environmental impact of power and heat production. There has been a convergence of heat and power systems so that fuel is now used to generate both heat and power simultaneously. The decentralised electricity system has allowed the penetration of efficient fuel cells into the heat and power sector – thereby further increasing the efficiency of fuel use - and also the expansion of renewable energy. It

has also enabled the emergence of the early stages of a hydrogen economy whereby fuel cell use is driving the convergence of heat, electricity and transport systems at the individual user level, and heralding the potential of a complete solution for the total replacement of fossil fuels in our energy system.

Sustainable energy production is composed of six main elements:

- *A decentralised locally focused electricity system;*
- *Extensive use of fuel cells for transport and for heat and power;*
- *A mature renewable energy industry;*
- *Combined heat and power in the industrial, commercial and domestic sectors;*
- *Some residual use of natural gas and oil; and,*
- *An emerging "hydrogen economy".*

3.4.2 The Decentralised Electricity System

The development of a decentralised electricity system has eliminated the unnecessary wastage which characterised the centralised electricity system of the 20th century. The decentralised system is dominated by micropower[59] with the majority of electricity being generated in small generating units which feed directly into local electricity networks. The local electricity networks form the focus of the UK electricity system and are highly flexible, connecting large numbers of electricity generators and consumers. The boundary between generator and consumer is very blurred because the majority of consumers are also generators due to the large numbers of businesses and households that produce their own electricity through CHP (micro and macro) and micro-renewables such as PV and microwind. The many local networks around the country are connected to each other so as to increase their robustness. Different regional networks are in turn interconnected which delivers an extremely stable electricity system. The wider grid system also plays the important role of transmitting around the country the fairly substantial quantities of power generated by the offshore renewables. This electricity is used as a top-up for the local electricity networks and also as a power source for large industrial users.

[59] See definitions of decentralised electricity and micropower in the Glossary.

Many electricity users (commercial and domestic) generate their own electricity and rely upon the local network as a means of back-up and as an outlet for selling their own power when they are generating more than they are using. The stability of the local network is maintained by its great flexibility and also the large numbers of generators and users which enables the local networks to be largely self-sufficient. The local networks are managed by the energy utilities which operate as "virtual utilities" and manage the stability of the network and the complex information flows concerning the highly dynamic sequences of micro-generation and use. The bills faced by customers take into account their balance of generation (selling to the network) and consumption (purchasing from the network), and include a general fee for access to the network (covering the cost of the virtual utility in managing the local network). Highly sophisticated microelectronic control systems enable the local network to operate at these very high levels of complexity and dynamism. These network control systems compliment the individual control systems that manage and balance the energy flows of individual customers and buildings so that users' requirements are instantaneously satisfied regardless of their own generation output. Local authorities have a substantial role in overseeing the terms and conditions that govern the utilities' responsibilities in managing the local networks. Not only is there substantial competition amongst the virtual utilities for operating these local network franchises but central government legislation ensures that the utilities will be penalised, and lose the franchise, if the stability of the local network is not maintained at a high level.

A number of energy sources power the decentralised electricity system, including:

- *Natural gas powered CHP, both micro and macro in the domestic, commercial and public sectors;*
- *fuel cell CHP;*
- *biomass powered CHP;*
- *micro-renewables, including microwind and PV; and,*
- *storage technologies, such as regenerative fuel cells.*

3.4.3 Net Metering

The flexibility and dynamism of the decentralised system means that net metering is a keystone component. The very rationale of the local electricity system is that micro-generators and users are interconnected via the local electricity network. This involves micro-generators contributing (selling) electricity to the local network as well as their using (purchasing) electricity from the network. Two-way meters are accompanied by highly sophisticated IT systems that monitor and control the highly dynamic interactions that take place.

However, for most electricity users, both domestic and commercial, electricity consumption is primarily controlled at the individual user level. Energy Service Companies (ESCos) balance site generation and consumption for their customers using sophisticated microelectronic systems. Most consumers generate their own electricity (micropower) and meet the majority of their own requirements, and they are connected to the many other micro-generators and users via the local electricity network. Domestic and commercial users generate their electricity from a number of different energy sources. Photovoltaics and microwind produce the majority of the domestic sector's electricity requirements along with the natural gas powered fuel cell and combustion combined heat and power units. There has been a convergence of the heating and electricity system due to the wide prevalence of CHP at both the micro and macro level.

3.4.4 Energy Storage

Energy storage technologies also play an important role in the decentralised electricity system. Regenerative fuel cells[60] have been used by the virtual utilities for some time so as to provide stability for the local electricity networks and to store electricity for periods of peak demand. In addition, this reduces the need for extra generating capacity in the local networks by enabling electricity to be saved when demand is at a low level for the times when demand is at a high level. However, micro regenerative fuel cells are now an essential component of most domestic and commercial individual buildings' electricity system. These enable individual users to save electricity when they are generating more than they are using, and are also part of the hardware that is managed by the ESCos. It decreases the level of

[60] See description of regenerative fuel cells in the Glossary

dependence of an individual user upon the local electricity network and also substantially increases the stability and capacity of the local network.

3.4.5 Fuel Cells

The efficiency of fuel cells, and the fact that they give rise to no pollution at their point of use, has resulted in their being a key component of the sustainable energy system of 2050 (see Glossary for a description of fuel cells and how they work). Fuel cells first penetrated the transport sector in the early 21st century but their use soon moved into the commercial and domestic sectors as a conversion technology for the generation of heat and power. In 2050 the majority of fuel cells run on reformed fossil fuels (methanol derived from oil for vehicles and hydrogen gas derived from natural gas for stationary uses) because hydrogen derived from renewable sources is not yet available in large quantities. Nevertheless, using fossil fuels with fuel cells is more efficient, and generates less carbon dioxide, than the use of combustion technologies because the electrochemical process in the fuel cell is an inherently more efficient conversion process (up to 80% efficient - excluding the reformation process) than thermal combustion (internal combustion engines are 20 – 25% efficient).[61] *Fuel cells are able to produce both power and heat (and the heat output can be increased and varied through the complimentary use of heat pumps), and as a result they represent the majority of combined heat and power units that are powered by natural gas. The remaining heat and power units are combustion based and fuelled by locally produced biomass. The use of efficient fuel cells with fossil fuels has thereby contributed to a reduction in the quantity of fossil fuel required to power our vehicles and provide electricity and heat for our buildings and homes.*

Carbon Composite, Fuel Cell Powered Vehicles

All vehicles are fuel cell powered, including private cars, buses, trams and trains. The majority of fuel cell vehicles are powered by methanol which is derived from oil. Therefore, although still dependent on fossil fuel, these vehicles are twice as efficient (in fuel terms) as the most efficient vehicles manufactured at the turn of the century

[61] From ENDS report 311 (December 2000) *On the Road to a Hydrogen Economy*

and thereby emit half as much carbon dioxide.[62] *As the majority of the vehicle fleet at the turn of the century consisted of inefficient models from the 1980s and 1990s, which were far less efficient than the most efficient model available, the average power system of a vehicle today is three times as efficient as it was at the turn of the century. As outlined above "hypervehicles" have completely penetrated the vehicle stock. These vehicles are extremely light and therefore require a third of the energy input required by steel bodied cars to drive them forward. The combination of ultra-light bodies and highly efficient fuel cell power systems have enabled today's vehicles to be 6 times as efficient as the vehicle stock at the turn of the century. Carbon dioxide emissions from transport are further reduced through a shift to public transport, cycling and walking, a reduced demand for mobility due to an expansion in telecoms use and a reduction in commercial traffic due to dematerialisation and the digital economy (as outlined in the previous section). The emerging hydrogen economy is providing a small amount of hydrogen fuel directly derived from electricity generated from renewable energy sources. When renewably produced hydrogen is used to power fuel cell vehicles then fossil fuels play no role in powering the vehicle and there are no emissions whatsoever associated with its use. See section 3.3.11 for more details of the emerging hydrogen economy.*

3.4.6 Combined Heat and Power

Combined heat and power is in extensive use across the UK which has enabled the efficiency of fossil fuel use for heating and electricity to double – because the same fuel is now used for both. In the centralised electricity system of the 20th century the majority of electricity generation occurred in large steam turbines without any heat recovery such that up to seventy percent of the energy from the fuel was lost as waste heat into the atmosphere. The fuel efficiency of the old coal power stations was between 30 to 35% whereas these modern CHP plants convert 70 - 80% of the energy content of the fuel into useful electricity and heat.

The use of CHP plants increases in the winter when the need for heat is at its greatest, and therefore their contribution to electricity supply is also at its greatest

[62] See ENDS report 311 (December 2000) *On the Road to a Hydrogen Economy* – methanol powered fuel cell vehicles emit half the carbon dioxide of modern efficient petrol cars, and all other pollutants are at least a fifth lower – full life-cycle emissions.

over the winter months, which is useful in substituting for the lower contribution of PV at this time (over the summer months PV provides up to three-quarters of the domestic sector's electricity use – see below). In the summer the CHP units are used more for their electricity generation than their heat output and at this time the fuel cell units are most useful because they can be re-adjusted to produce all electricity and no heat – and vice-versa in the winter months.

Large CHP in the industrial, commercial and public sectors

Large CHP units powered by natural gas (either directly in a combustion plant, or as a hydrogen source for fuel cells) and biomass are a significant contributor to heating and electricity needs. The majority of the biomass is from energy crops which represent 10% of UK agriculture. CHP represents the main heat and electricity source for the commercial and public sectors in which fairly large units serve large buildings.

A number of community heating schemes fuelled by sustainably grown biomass are still in existence. These CHP plants also generate electricity for the local community, and use clean burning technologies such as fluidised bed combustion and gasification. Community heating schemes were already in common use on the continent in the 20th century, and they became popular in Britain in the early part of the 21st century. However, the high energy efficiency benefits of fuel cells and improvements in the technology of individual site micropower meant that these began to replace community heating and electricity schemes after 2030.

Micro Combined Heat and Power

The CHP units in the domestic sector are far smaller than those in commercial and public buildings. Heating in the domestic sector is provided by small biomass and natural gas powered combustion or fuel cell CHP units. Both these types of micro CHP unit are extremely energy efficient, although the fuel cell is more efficient and is beginning to dominate the market place. The heating requirements of the domestic sector are less than half what they were at the beginning of the century and they are met in the main by biomass powered CHP units with support from heat pumps.

3.4.7 The Development of the Decentralised Electricity System

The decentralised electricity system has developed over the past fifty years due to a number of legislative, institutional and market changes which have encouraged technological and system changes. The government's gradually increasing carbon tax encouraged (continued) the switch to natural gas as the main fuel for electricity generation, it is also encouraged CHP and the development of renewable energy. Smaller-sized electricity generation is more suitable for CHP so that the heat can be put to good use in the near vicinity – either in the building itself or to sell to other users nearby. Alongside this, a large number of commercial electricity consumers, such as those using large amounts of IT equipment, began to become more and more concerned about the reliability of their electricity supply – since any reductions in the quality of their electricity supply can bring down their IT systems and cost them a lot of money. By generating their own electricity in a micropower unit, the user can ensure that the quality is at the standard required. As the 21st century progressed and the importance of IT grew and grew, so did the availability of very high quality power supplied by micropower systems. In the longer-term this also encouraged the commercial uptake of fuel cells for electricity generation in the IT sector because they provide almost 100% reliability of supply.

Increasing fuel and electricity prices also made it more financially preferable for businesses, and large public users, to invest in their own combined heat and power plants rather than purchase both electricity and fuel separately. In addition to the market drivers for renewable energy (i.e. the increasing cost of conventionally generated electricity) government support for renewable energy came in the form of legislative requirements on the energy utilities and the instigation of community lead renewable energy development. Increased political support from government, and from the public as a whole, contributed to their increasing role in electricity and heat generation. Micro-renewables, such as PV and microwind, became popular as the electricity system became more decentralised and the robustness of the local networks increased. The statutory requirement for all new electricity meters to be two way also helped in the development of the decentralised electricity system as a whole and the development of own generation in the domestic sector as well as the commercial sector. As the quantity of decentralised generation increased the technologies surrounding the deliver of micropower also increased so that the robustness and sophistication of the local networks improved. Energy companies

gradually realised that the future of power supply lay in micropower and so investment in the technologies increased substantially. The environmental externalities associated with the centralised electricity system – and its inefficient use of fuel – and the reliability and efficiency of micropower have contributed to this complete transition to a decentralised electricity system.

3.4.8 Renewable Energy – The Main Energy Source

Renewable energy sources play a pivotal role in electricity generation in 2050. Renewable energy and fossil fuels each supply about fifty per cent of the UK's energy needs. The quantity of energy harnessed from renewable energy flows has increased by approximately fifteen fold[63]*. The majority of the energy from renewable sources used by society is in the form of electricity, and is from the intermittent renewable sources which includes onshore and offshore wind, wave, tidal stream, solar and small-scale hydropower. Energy crops and biomass play a useful role in heat provision as well as electricity production through the widespread use of combined heat and power systems. Passive solar also contributes a significant amount to heating and lighting requirements through better building design (see above).*

Onshore and offshore renewables each provide approximately half of this electricity. The offshore renewables help to boost the locally generated electricity and large power lines under the seabed bring the offshore power to the land distribution networks. Onshore wind constitutes the largest quantity of locally generated electricity. The majority of wind farms are community owned and provide electricity directly for the local community. Energy crops have substituted for approximately 10% of agricultural land and the vast majority is short rotation coppice (SRC). Energy crops have provided a useful economic outlet for many farmers and are now a familiar component of agricultural life. The SRC provides a good habitat with biodiversity levels higher than in any other organically produced crop. The SRC is grown locally to the small CHP power stations which provide electricity and heat for local communities. The energy crops supply countless community heat networks across the country. All UK buildings have their roofs and southerly facing upper

walls clad in photovoltaic panels (PV). These PV cells provide the majority of the domestic sector's electricity needs[64] *and with the back-up of other local renewables, local electricity networks are often self-contained. PV is also a large contributor to the commercial sector's electricity requirements as office buildings have large surface areas open to the sun. PV cells substantially fell in price during the first two decades of this century due to the benefits of economies of scale that came with large-scale manufacturing and the technological development over this period. Over time they have fallen to a price that is only a little more expensive than ordinary roofing and cladding materials.*

Offshore wind, wave and tidal stream energy generate large amounts of back-up electricity for the local electricity networks that power the domestic and commercial sectors. They also provide for industrial use of electricity. However, some offshore renewable resources have also begun to be used to generate hydrogen to fuel the emerging hydrogen economy – as is outlined below.

The vision does not include any new large-scale hydropower schemes or a tidal barrage due to their large environmental impacts. The vision incorporates all other renewables including onshore and offshore wind, small-scale hydropower, solar, biomass, agricultural & forestry wastes, wave, tidal stream and geothermal power. With the exception of offshore wind, these are all based upon smaller technologies and structures so their environmental impacts tend to be smaller and more localised than fossil fuel and nuclear electricity generation. However, as offshore wind will be located out at sea its visual impact will be fairly small when viewed from onshore. Energy from waste (the incineration of municipal waste) has no role in this vision. Other than the fact that unsorted municipal waste is not a truly renewable resource (for burning), its components are now of too high a value to the recycling industry for incineration. The reduction in waste arisings over the course of the century and the corresponding growth in recycling rates (and development of closed loop manufacturing systems) has almost eliminated the concept of waste. Biomass is used

[63] Based on energy scenarios 2 & 3 from the Royal Commission on Environmental Pollution's recent study, "Energy – The Changing Climate".

[64] ETSU estimate the resource capacity of PV (when on all UK roofs) to be 266TWh per year. This corresponds with an overall UK electricity consumption of 379TWh in 1999. *New and Renewable energy: Prospects in the UK for the 21st Century – Supporting Analysis, ETSU, 1999*

as a fuel for heat and power only and is not used to power transport because it represents a more efficient use of biomass fuel. The process of producing transport biofuels, from crops such as oil seed rape, is fairly energy inefficient and is also quite polluting, and would have only a small impact on the quantity of fossil fuel used by the transport sector[65].

3.4.9 The Landscape And Environmental Implications Of This Renewables Intensive Vision

This 2050 vision does not involve exploiting every last joule of energy in the natural environment – it only requires about a quarter of the total available UK renewable energy resource.[66] *The residual use of fossil fuels and the improvements in the efficiency with which energy is used mean that the UK does not need to exploit its renewable energy sources to their extremes. Substantial implications for the land and seascape, and potential effects on terrestrial and marine wildlife are therefore avoided. In addition, the public have become highly accepting of renewable energy infrastructure through community ownership of renewable energy schemes and due to the fact that they are now aware of where they energy comes from - which also encourages them to use energy efficiently. Good environmental management keeps the environmental impacts of renewable energy to a minimum.*

The development and construction of renewable energy plants has always followed clear guidance and consultation so that the environmental implications of renewable energy have been sensitively managed and have a clearly demonstrated sustainability benefit. The high efficiency of modern wind turbines has meant that they have not needed to be sited at the very highest wind speed sites in order to be economic. Therefore, it has not been necessary to position wind farms in all the most visible locations across the country on top of every hill and mountain in the British Isles. This has enabled wind turbines to be more effectively absorbed within the character of the landscape. Energy crops are an agricultural product and their expansion has been subsumed within the character of the agricultural landscape.

[65] The Royal Commission considered the use of energy crops for heat and power purposes to be more energy efficient and with more environmental benefit than energy crops for transport. See pages 137 to 139, *Energy – The Changing Climate,* the twenty-second report of the Royal Commission on Environmental Pollution. June 2000

There has been only a very small increase in the overall area of agricultural land in the UK to enable increased energy crop production – on the whole energy crops have been a substantial economic benefit to farmers and it has allowed them to diversify. In addition to this short rotation coppice provides a better habitat than most other crops.

The small number of very large power stations that characterised the centralised electricity system have been replaced by higher numbers of much smaller power stations (CHP stations). These stations blend into the UK landscape far more effectively than the large stations of yesteryear and go largely unnoticed in the urban environment where they are smaller than many other buildings. Most biomass powered stations are gasification plants which have low emission levels and have a negligible impact upon local air quality.

The photovoltaics industry has an almost 100% recycling rate, and specialist PV cladding companies return the old and broken PV cells to the manufacturers. This ensures that the potentially dangerous chemicals inside the PV cells do not harm the local environment, and it contributes towards the closed loop sustainable manufacturing system, such that the environmental impact of manufacturing PV is kept to a minimum.

3.4.10 Community Ownership of Renewable Energy Schemes

A large proportion of the UK's on-shore renewable energy plants are owned or joint-owned by the local community. The development of renewable energy followed an extremely successful model of community and stakeholder participation. The decision-making process engaged all members of the community and the sites for renewable energy schemes were chosen and allocated at the regional and local level by the local authority and local community rather than the developers themselves. As a result there has always been widespread acceptance of renewable energy infrastructure and an enhanced understanding of where energy comes from which has in turn promoted a greater awareness of energy use and the need to use it efficiently.

[66] See section 4.4 below for an estimate of the UK's total renewable energy resource and an estimate

3.4.11 The Emerging Hydrogen Economy

The increasing penetration of fuel cells over the course of the century and the increasing output, and improved conversion efficiency, of renewable energy has meant that the "hydrogen economy"[67] has gradually become more and more of an emerging reality. The efficiency and reliability of fuel cells has seen their expansion from the initial domain of transport into stationary uses, such as electricity and heating generation for buildings. Due to the huge resources of offshore renewable energy that are available, the large offshore wind, wave and tidal stream electricity generating stations have begun to be extended with the purpose of generating electricity so that hydrogen can be produced.

As the price of natural gas begins to climb due to depleted reserves in the North Sea and there is increased demand on the Siberian natural gas reserves, the economic favourability of renewably produced hydrogen is beginning to increase. The infrastructure for the hydrogen economy will however take some time to develop, but as it does the need for petroleum and natural gas will become smaller and smaller. The hydrogen is generated by undertaking the electrolysis of water using renewably produced electricity. This hydrogen is then piped ashore to feed a growing number of hydrogen sub-stations which distribute the gas to hydrogen filling stations around the country to replace reformed petrol as the fuel for fuel-cell vehicles, and to provide for the growing number of domestic, commercial and industrial fuel cells for electricity and heat that are powered directly from hydrogen gas rather than reformed natural gas. The "hydrogen grid" is at the moment very small but it is beginning to take shape connecting the main offshore renewable farms with key transport corridors where demand for hydrogen fuel is high.

of the renewable energy requirements of this vision.

[67] See Glossary for a description of the Hydrogen Economy

4 ASSESSING THE SUSTAINABILITY OF THE VISION AND ITS ALTERNATIVES

4.1 The Unsustainability of Continued Growth in Fuel and Electricity Use

The UK needs to grasp the opportunities presented in this vision for improving energy productivity so as to reduce the wastage that characterises our current energy system. The alternative is for the UK to face a continuously increasing fuel and electricity consumption which would put significant pressure on all of the energy sources available to the UK. Huge economic, social and environmental impacts would result from large and continued increases in the use of fossil fuels and nuclear power, or from large and continuously growing renewable energy exploitation. The vision presented in this document attempts to decouple economic growth and energy use through radical improvements in energy efficiency and dematerialisation of the economy. This is a key sustainability challenge that has to be addressed if we are to achieve a sustainable energy future. The alternatives to this vision are all based upon a large and increasing UK energy demand. It would be foolhardy indeed to pin all our hopes upon the discovery of an extremely cheap and totally environmentally benign energy source.[68] In fact, it is extremely unlikely that such an "energy miracle" will ever be discovered, and yet unless this were to happen then an increasing energy demand would result in increasing economic and environmental costs.

In the face of continued increases in energy demand the UK could theoretically meet its energy needs in a variety of ways, based upon different combinations of fossil fuels, nuclear power and renewables. Although the sustainability implications of these energy sources are profoundly different, they all meet sustainability limits if fuel and electricity consumption continues to grow due to inefficient use.

Ultimately an upper limit exists to the quantity of natural ambient energy that is found in the sunlight, wind, wave and tidal energy flows which pulse through the British Isles. Even when taking into account continuing improvements in the

[68] The Royal Commission on Environmental Pollution determined that "even if the technical viability of nuclear fusion can be established, it would not be prudent to base energy policies on the assumption that it will become competitive in cost with other non-carbon energy sources in the foreseeable future", and "that (if technical viability is established), commercial scale demonstration

performance of renewable energy technologies it is undoubtable that if UK society were to continue "demanding" ever more energy in the inefficient manner in which it currently manages its energy flows then this upper limit would eventually be reached. And any attempt to capture every last joule of energy from our natural environment would lead to unacceptable environmental and economic impacts. But it is clear that this same upper limit would eventually be faced whatever energy source/s we choose to exploit, be it renewable energy, nuclear power or fossil fuels. We are already beginning to reach the environmental limits to fossil fuel use – in the form of accelerated climate change – even before this non-renewable resource begins to physically run out. There are a number of limits to nuclear energy use, including the problem of managing and finding enough disposal sites for an ever increasing quantity of radioactive waste. A satisfactory disposal method for radioactive waste has yet to be developed. Uranium is also an exhaustible resource – and one that is even more scarce than fossil fuels unless research into fast breeder reactors achieves success. It is difficult to envisage a sustainable world in which energy demand continues to expand indefinitely – such a society would inevitably meet economic as well as environmental limits regardless of significant technological advancement.

The Royal Commission on Environmental Pollution's four alternative climate-friendly energy scenarios for 2050 also provide a useful lesson about the sustainability benefits of using energy productively. The first scenario has the highest energy demand (although it nevertheless represents a stabilisation of 1998 energy demand up until 2050) and in the light of substantially reduced fossil fuel use, it has huge nuclear and renewable energy infrastructure to satisfy this demand. Although the second scenario is powered by only renewable energy and a reduced fossil fuel input (i.e. no nuclear contribution), it nonetheless has less renewable energy infrastructure than in scenario 1 because of a reduced energy demand (36% reduction on the 1998 energy demand). This demonstrates the importance of using energy efficiently so that the scale of energy supply infrastructure, and its corresponding environmental impacts, can be reduced. In terms of a sustainability hierarchy the opportunities for improving the productivity of our energy use come first. It is difficult to argue against the sustainability merits of a vision of a highly

plant would still be unlikely before 2050". As yet the environmental implications of fusion remain

energy efficient society – particularly when it is recognised that the exploitation of any energy source has an environmental impact because it represents the use of a resource or the natural environment. A continuation of the profligate energy use of today will simply put society on a crash course with the environment, and in the opposite direction to sustainable development.

4.2 The Unresolved Key Sustainability Impacts of Nuclear Power and Fossil Fuels

Achieving high levels of energy efficiency represents the first part of a sustainable energy future. This 2050 vision argues that decentralised renewable energy and, for the foreseeable future, a reduced fossil fuel contribution represents the supply side of a sustainable energy future. This vision takes as its starting point the pressing need for reductions in fossil fuel use as the only means of addressing climate change. This requires changing the source of energy as well as improving the efficiency with which that energy is used. The only two main options available today, and for the foreseeable future, are nuclear power and renewable energy. Of these two energy sources renewable energy is by far the most sustainable option when exploited at the scale presented in this vision.

Nuclear power raises a number of key unresolved sustainability issues, such as:

- The on-going debate about the disposal of **high level radioactive waste**. Of course, the quantities of waste would increase under an increased deployment of nuclear power and so this issue would grow in importance. As yet there is no satisfactory method of disposing of this waste;
- The **decommissioning** process has only just begun for the earliest Magnox reactors. This will be such a long process that only time can tell as to the problems it may encounter and the overall financial costs;
- **Uranium**, the fuel of existing power stations, is a **non-renewable resource** that at current mining rates probably has a life-span of less than one hundred years. For this reason unless commercial fast breeder reactors which can use plutonium

to be clarified.

as a fuel can be safely developed then nuclear power itself will not be a long-term energy option;

- If the UK were to choose nuclear power as its main energy source for the future it would send out to the rest of the world the message that nuclear power is the answer to climate change and all the other environmental and economic challenges involved in achieving sustainable energy. This may send the signals for a more nuclear intensive world, and all the dangers this raises of **nuclear proliferation**, increased nuclear shipment and transport, and weaker safety standards in poorer countries; and,
- The **potential threat of a nuclear disaster** would always be with us. However high the levels of safety at nuclear facilities the potential occurrence of human error or electronic malfunction can not be ruled out altogether – particularly if the handling of nuclear material were to increase substantially. Although nuclear advocates often point out that nuclear installations follow far higher safety criteria than other activities that present potential environmental harm – it is clear that these safety levels need to be very high due to the extremely dangerous nature of nuclear substances and processes. A breach of containment can be irreversible if high level radioactivity leaks into the natural environment. This irreversibility element of a potential safety breach does not fit in well with the principles of sustainable development.

The large-scale management of radioactive material raises substantial sustainability issues, and is unlikely to be a component of many peoples' vision of a sustainable world. For this reason nuclear power is only likely to be welcomed as a "sustainable" energy source if it is clear that its use is essential – i.e. that we have no other option. But this is simply not the case, as this vision seeks to illustrate. The Royal Commission on Environmental Pollution were also clear in stating their disagreement with the assertion that nuclear power is essential to the delivery of a climate friendly energy system.

This 2050 vision takes as its starting point the need to reduce fossil fuel use as a means of decreasing carbon dioxide emissions. However, it could theoretically be possible to reduce carbon dioxide emissions without reducing fossil fuel use through

the natural sequestration of carbon dioxide by plants, or the technological removal and storage of carbon dioxide. There is general scientific agreement that carbon sequestration is not a reliable way by which to reduce carbon dioxide concentrations in the atmosphere and it is well recognised that it is likely to be able to play only a supporting role in mitigating climate change. The technological removal and storage of carbon dioxide is also a possibility. However, it is likely that it would be very expensive to undertake this approach – particularly considering the millions of dispersed sources of carbon dioxide, and there is some uncertainty over whether the storage of carbon dioxide would be secure. For these reasons the Royal Commission on Environmental Pollution determined that these carbon removal strategies should be below fossil fuel reductions in the hierarchy for addressing climate change, and that,

The core of a global response to the threat of climate change must be the most effective and reliable forms of action, those which reduce the amounts of carbon dioxide produced by burning fossil fuels.

4.3 The Compatibility of Renewable Energy with a Sustainable Society

The environmental issues posed by renewable energy are not in the same magnitude as those for nuclear power and fossil fuels, and its sustainability implications are far more positive. The renewable energy sources contributing to this vision consist primarily of the smaller, more local renewables. The vision does not include any new large-scale hydropower schemes or a tidal barrage due to their large environmental impacts. The vision incorporates all other renewables including onshore and offshore wind, small-scale hydropower, solar, biomass, agricultural & forestry wastes, wave, tidal stream and geothermal power. With the exception of offshore wind, these are all based upon smaller technologies and structures so their environmental impacts tend to be smaller and more localised than fossil fuel and nuclear electricity generation. However, as offshore wind will be located out at sea its visual impact will be fairly small when viewed from onshore.

In the UK the environmental impact of renewable energy that has caused most concern is its visual impact upon the landscape. This is particularly the case for

onshore wind turbines which are otherwise essentially environmentally benign in their generating phase. However, this visual impact should be considered alongside the visual intrusion that our electricity system already imposes upon the UK landscape, and in particular the twenty-two thousand pylons that criss-cross our countryside. The visual presence of a wind turbine or farm is not considered to be an environmental impact by everyone. Whether it has a negative aesthetic impact or a positive aesthetic impact is determined according to personal taste and its specific location. Although a change to the landscape can definitely be classified as an environmental issue, the impact it has upon quality of life and sustainability is difficult to assess because preferences can change on the matter. It should also be pointed out that although wind farms affect the appearance of the landscape they do not affect the nature or use of the land unlike many other forms of development. Although personal values are very important in determining sustainability impacts it is difficult to equate aesthetic issues with the fundamental sustainability risks that continued fossil fuel use and nuclear power pose to natural systems at the global, regional and local level.

Although the various renewable energy technologies have specific local environmental impacts these can be managed and are not at the same level of complexity or environmental harm as the problems presented by nuclear power. For example, raw materials are required in the construction of all renewable technologies and their associated infrastructure, and the manufacture of photovoltaic cells requires rare metals. In addition to this, small-scale hydropower, tidal stream and wave power can have some local wildlife impacts. Large scale use of biomass will require fairly large areas of land and agricultural inputs for growing energy crops, and the non-carbon emissions from combustion plants need to be controlled. As long as good environmental practice is followed (as it is in the 2050 vision) these impacts can be mitigated and controlled. Sustainable manufacturing and high levels of recycling can reduce the impact of raw material use, and sustainable agriculture techniques and clean burn technologies can reduce the impacts of biomass energy production.

Nevertheless, renewable energy represents a continuously renewable resource. It leaves no enduring pollution or contamination, and presents no threat to human health. Upon decommissioning renewable energy technologies can be removed from

the site with no lasting impact or clean-up requirements (although photovoltaic cells need to be carefully managed due to the presence of toxic substances). This is not true of fossil fuels or nuclear power, and it is for this reason that renewable energy tends to be equated with sustainable energy. Indeed, a number of studies of the environmental impacts of renewable energy sources have suggested that unlike fossil fuels and nuclear power, renewables pose no fundamental sustainability problems as long as their development is managed sensitively, and framed within general steps towards sustainability in society at large.[69]

4.4 The Resource Capacity of UK Renewable Energy Sources

The potential resource capacity of renewable energy is very large indeed. The Energy Technology Support Unit (ETSU) has provided an assessment of the potential resource capacity of each of the different renewable energy sources in the UK. These estimates add up to a total accessible resource of approximately 2,500 TWh per year[70]. This equates to 25% more than the UK's total energy consumption in 1999[71] – even when taking into account the high levels of inefficiency which characterise the UK's use of energy. The exploitation of renewable energy in this vision amounts to about a quarter of current overall energy use – and therefore less than a quarter of the estimated renewable energy resource. This total renewable resource estimate only includes realistically accessible sites and therefore, excludes wind power from areas where land-use does not permit turbine siting (i.e. all urban areas, woodland, lakes, streams etc). It also excludes all landscape and wildlife designated sites (i.e. SSSI, National Parks, AONB, etc) and sites where wind levels are low and electricity generation would be inefficient. The energy crops were only calculated for 10% of agricultural area and offshore wind excluded main navigational areas and areas where water depth is unsuitable for siting, even though floating platforms are a technical probability. Similar constraints were allocated for all the other renewable energy sources. In fact, the resource could be much larger for some technologies if the number of sites considered available were to be increased,

[69] See for example "Renewables in Power Generation: Towards a Better Environment", ETSU 1998, and "Renewable Energy: A Sustainability Analysis Using The Natural Step", The Natural Step, November 2000.

[70] From *New and Renewable Energy: Prospects in the UK for the 21st Century – Supporting Analysis,* ETSU 1999 and *Study of Offshore Wind in the EC,* JOUR 0072, Verlag Naturliche Energie.

[71] The *Digest of United Kingdom Energy Statistics 2000* lists the total UK end-use energy consumption for 1999 at approximately 2000 TWh or 170 MTOE.

such as for wave power where only the best sites were included and PV which was restricted to buildings.

However, the UK is never likely to want to exploit every single renewable energy site – even at the most technically and practically suitable offshore renewable energy areas. Nevertheless, this estimate of the overall accessible resource usefully demonstrates the huge quantity of renewable energy that is potentially available for our use. The overall resource capacity of renewable energy sources is never likely to be a limiting factor in terms of renewable energy's ability to power our society. However, the over-bearing physical presence of renewable energy infrastructure need never become a limiting factor either, because truly sustainable energy use will not require society to exploit renewable energy to that degree. Instead, the attainment of sustainable energy - in the form of highly flexible local energy networks that dynamically balance supply with use – will enable renewable energy to be in balance with our landscape and local environment. In these circumstances local communities will enthusiastically embrace renewable energy schemes, recognising their assistance in the delivery of a sustainable society.

The Royal Commission on Environmental Pollution's energy study presented four alternative energy scenarios for 2050 illustrating how the UK could reduce its fossil fuel use by 60%. Each of these scenarios has a high renewable energy contribution and scenario two and four consist of a similar energy system to the one presented in this vision – with substantial energy efficiency improvements and a renewable energy and fossil fuel reduced energy input. These scenarios also provide an indication of the environmental implications of a renewable energy based future by quantifying the renewable energy infrastructure that is required. Scenario two presents a similar level of renewable energy generating capacity to that presented in this vision (although renewable energy contributes a smaller proportion of the overall energy supplies in the RCEP study because fossil fuel use has been reduced by only 60% - as opposed to 75% in this vision – the overall energy demand is higher with a 36% reduction on today's levels as opposed to a 50% reduction in this vision). As an indication of the landscape implications of this vision the calculations of the likely quantity of renewable energy generating infrastructure for scenario two is briefly outlined below.

The study estimated that approximately 5,000 wind turbines would be required on the UK mainland . This may appear to be a very large number when compared with the thirty or so large fossil fuel and nuclear power stations that provide up to two-thirds of today's electricity (smaller gas power stations provide over a third of our electricity but are not as visible as the older very large coal and nuclear stations). However, it should be noted that there are presently approximately 22,000 electricity pylons across the UK – in fact if a 1 MW wind turbine was built at each pylon site then 60% of the UK's current electricity demand would be met.[72] These wind turbines could be located across the whole of the UK, and although Scotland, Northern Ireland, Wales and the north and south west of England have the biggest wind resource, the Midlands and south east of England also has an exploitable wind resource.[73]

The scenario also included 18,000 offshore wind turbines, 7,500 wave power units, 500 tidal stream units, 8 million buildings with PV arrays (i.e. 50% of the UK building stock), 4,500 small-scale hydropower schemes and up to 3,000 small biomass CHP plants (this amounts to 1.2 biomass plants per each 100 square kilometres across the UK and energy crops taking up to approximately 10% of UK farmland area). It is expected that the offshore wind turbines would be visible on the horizon from much of the UK coastline and would require new transmission lines at a number of locations on the coast (although the transmission to land would be under the sea-bed and new transmission on-shore could also be laid underground). The biomass power plants would be very small ones producing only about 1MW (the same as one wind turbine). The small-scale hydropower units are extremely small and only have a small visual presence on the stream or river.

This level of renewable energy exploitation would not lead to unacceptable landscape impacts, and the quantity of renewable energy plants is not that large. In addition the renewable energy infrastructure could be well-designed so as to keep it in character with its local environment. It could be argued that our present day

[72] "Energy: Clean and Green by 2050", Centre for Reform 1999, Laura Brodie and Andrew Stunell

centralised electricity system, has a similar – or even larger landscape impact – due to the immense size of the coal and nuclear power stations, and their complete dominance of the local environment in which they are located (in fact, the large coal power stations in Yorkshire have an impact on the whole region's environment).

[73] The British Wind Energy Association argues that each region in the UK should contribute to the 10% electricity target, and that wind energy can be competitive in lower wind speed sites (as it is on the continent).

5 REALISING THE VISION – ECONOMIC AND SOCIETAL CHANGE

5.1 The Contribution of this Vision to Achieving a Sustainable Economy

This sustainable energy vision will contribute to the wider delivery of a sustainable economy. Although climate change is the most urgent and important environmental impact arising from our excessive use of fossil fuels there are many other sustainability issues associated with our use of fuels and electricity. The UK Government's sustainable development strategy[74] outlines the many other requirements for achieving sustainability. To name just a few this includes the need for radical improvements in the resource efficiency of our economy, reducing the amount of waste we produce and increasing recycling rates. Achieving these many goals will require substantial changes in the functioning of every sector of society. Many energy analysts ignore these wider aspirations of sustainable development, and the fact that our use of energy is intricately linked to our use of other natural resources, when considering options for reducing greenhouse gas emissions. As a result they perceive the challenge of sustainable energy to be that of enabling reductions in our carbon dioxide emissions whilst supplying the energy we need for our current unsustainable economy and way of doing things.

As sustainable development requires substantial changes throughout our society and economy then it follows that our present day economic activities that depend upon our present day energy system will substantially change in the future, and vice versa. As our economy changes substantially over the forthcoming century (in line with the sustainable development process) then the energy needs of our economy will also change. The success of a future sustainable energy system will not be measured by its ability to supply copious amounts of energy with as small an environmental impact as is possible (with the subsequent arguments over which are the "worst" impacts) but by its contribution to (and its place within) a truly sustainable economy. Thus, changes in our energy system will go hand in hand with other fundamental changes, such as improved resource efficiency in manufacturing, dematerialisation in the delivery of services and changing transport patterns in our communities. This 2050 vision recognises the wider sustainability context inherent to the sustainable

energy challenge and presents an energy system that is consistent with, and will contribute to, the many components of a sustainable economy.

5.2 The Vision – Driving Economic Structural Change for Sustainable Energy

The transition to this sustainable energy vision will involve structural economic change. The industries surrounding fossil fuel use (and inefficient fossil fuel use) – such as oil exploration and extraction, the internal combustion car manufacturing industry, and those industries that use energy inefficiently - will gradually contract and eventually disappear. And over this same transition period new replacement industries will develop, such as renewable energy, energy efficient equipment, energy management markets and high energy performance industries. The early stages of this process are already beginning to take place. Over the coming decade the basis of competition in the energy markets will change and focus on low carbon energy service delivery. Under these new terms of competition there will be those who lose out, and they will put up resistance to the policy measures encouraging a low carbon economy. Clearly, the concept of market competition is that there will be winners and losers - and therefore any process of economic change will result in winners and losers. In the economy as a whole the development of a renewable energy industry coupled with a bigger "energy service industry" focused on efficient equipment and subtle management, will counteract the job losses associated with the old way of doing things. In the long-term the UK will not face "substantial economic cost" but simply undergo structural economic change. Sustainable development will come across this particular issue in many guises because it requires change in the way we do things – and with any change there are losers as well as winners.

However, this process of economic change is likely to be erroneously perceived as an economic cost. This is evident even with something as small as the Climate Change Levy. The industrial trade bodies have lobbied against the levy describing it as an unacceptable economic cost on British business even though it will have the benefit of encouraging industry to use energy more efficiently – and the current inefficient use of energy represents a substantial economic cost on British business.

[74] A Better Quality of Life – A Strategy for Sustainable Development for the UK, The Stationery

The economic benefits (and industrial competitiveness benefits) of improving energy efficiency in the UK are simply not recognised. The Climate Change Levy is in fact going someway towards correcting the market place by internalising the externalities of fossil fuel use. But this wider view of economic benefit is not understood by those who are hostile towards any changes in their current market conditions.

The resistance to economic change tends to be large even when the forces driving change in market conditions are largely external and can not be controlled by government, such as the technological and cultural drivers behind the general decline of heavy manufacturing industry in the UK. Therefore, industrial resistance is likely to be even more powerful when the instigator of change is the government. Those companies and employees who are affected by policy and fiscal measures are unlikely to appreciate that the purpose for changing market conditions is to remove market distortions which are causing severe environmental damage so as to encourage long-term restructuring of the economy along more sustainable lines. Resistance is likely to be very large – particularly when these measures are wrongly perceived as having a negative impact upon the economy. This in turn will have a negative effect upon the sustainable development cause by reinforcing the false dichotomy of jobs versus the environment.

It will be important that society recognises that the economic change in our energy industries that will accompany this energy vision is part of the transition process to a sustainable economy – and not erroneously perceive the change as a negative impact on the economy forced by environmental considerations. A whole raft of economic benefits can be obtained from encouraging improvements in energy efficiency and increasing the contribution of renewable energy. If the transition is gradual and well managed then there should be few negative implications for the economy and society. Research undertaken by Cambridge Econometrics and Forum for the Future (using a complex economic model) into the achievement of the 20% carbon dioxide reduction target by 2010 (which included a large contribution from renewable energy) determined that it would lead to a very negligible impact upon the growth of the economy in the short-term whilst at the same time developing new industrial and

Office 1999

employment opportunities, and long-term growth potential[75]. The Royal Commission on Environmental Pollution report also states that there is no reason to believe that substantial changes to the energy system would lead to large economic impacts upon the UK. This suggests that they were in agreement with a background paper for their study provided by Paul Ekins and Robin Cotton which after reviewing the issues surrounding long-term change in energy markets, concluded[76]:

"...there are no grounds for thinking that the transition over the course of the twenty-first century to a low or no carbon energy system will be expensive, or even incur any costs at all, apart from those of proactive government policy. The transition is better perceived as a guided fundamental structural change in a world where such change, guided or not, is occurring the whole time."

Realising this vision will help drive the structural economic change that is necessary for sustainable energy and sustainable development as a whole, and for the realisation of a prosperous affluent society.

The policies and powers of the European Union will also be important in the achievement of this sustainable energy vision. The realisation of the vision is very dependent upon the market – it requires the internalisation of the environmental costs of fossil fuels and inefficient energy use and also the dynamism and innovation of the market in order to find solutions and speed technological development. The UK operates in the wider EU marker place (and in the world market outside this), and therefore in order to implement some economic instruments it will require the cooperation of the EU as a whole. If the UK was to unilaterally raise its energy price by a significant margin so as to encourage efficiency or alternative energy sources then it might put its energy-intensive industry at a disadvantage to similar industry in other countries. This would particularly be a problem if energy prices were very low in other countries which would probably put British energy-intensive industry at a disadvantage over the transition period before its efficiency levels had time to

[75] Forum for the Future (1999). *The 20% Solution: Meeting the Government's Targets On Climate Change.*

[76] Cotton, R. and Ekins, P. (1998), *What Energy System for the UK in the 21st Century?* (A background paper for the Royal Commission on Environmental Pollution study on energy and the environment. Imperial College of Science, Technology and Medicine and Forum for the Future.

improve. However, even those industries for which energy efficiency improvements would easily make up for higher energy prices are still likely to put political pressure on the UK government because they will perceive themselves to be at a disadvantage due to the lower prices facing the rest of Europe. If the price increase is harmonised across the EU then this perceived economic impact would no longer be a political problem.

5.3 Delivering the Sustainable Energy Vision – A Societal Transformation

Delivering this sustainable energy vision will involve substantial societal change. The UK Government's sustainable development strategy recognises that we need to change the way our society and economy operate if we are to avoid undermining the environment and resources upon which we depend. Maintaining the same economic development pathway represents too high a risk to the long-term survival of modern society. Therefore, in undertaking sustainable development, the one thing that we should not be afraid of is the process of change. However, there are many barriers to change built into our society and institutions and there is a natural resistance to change within ourselves. Many people in government, business and other decision-making positions are cautious in undertaking change and recognise the many risks it brings – business risks, economic risks, societal risks and even environmental risks. Society needs to do things differently – it needs to face these risks and enter the unknown. Sustainable development is a learning process and the solutions will reveal themselves as we undertake the change process.

A hesitant approach to sustainable energy, and sustainable development in general, is hampering the practical and policy changes that are necessary to stimulate the economic and societal transformations that sustainable development requires. Decision-makers like to have full information and knowledge before undertaking action – even though the uncertainties and unknowns which plague sustainable development often make this impossible. This tentative approach to sustainability decision-making is in direct conflict with the principle of experiential learning which is a core element within the concept of sustainable development. It is impossible to paint an exact picture of tomorrow's world, just as it would have been impossible to accurately predict the world of today fifty, or even twenty, years ago. Sustainable

development requires us to instigate changes today, and to use our imagination about what can be achieved tomorrow.

The biggest challenge facing this energy vision is the general lack of public and political interest in the many opportunities available for changing our energy system. Changing our energy system needs to become more of a priority political issue. Unless there is a determined societal commitment to improving energy productivity and enabling the decentralisation of electricity production and expansion of renewable energy then the vision is unlikely to be realised. The potential for positive technological and institutional change is out there but the opportunities will only be realised if they are nurtured through societal and political commitment. The Royal Commission on Environmental Pollution captured this point elegantly when they quoted from Charles Dickens' "A Christmas Carol" at the front of their recent energy report,

Are these the shadows of the things that Will be,
Or are they shadows of things that May be, Only?

5.4 Stimulating Innovation – An Important Component of the Vision

This sustainable energy vision is based upon the many opportunities for improving our efficiency of energy use and developing renewable energy. However, although many promising technological solutions are available today there is still a lot of innovation and development that is needed before this 2050 sustainable energy vision can become a reality. The vision outlines the use of the power of the market place, coupled with well targeted legislation, to encourage dynamic innovation that can deliver complete energy services based on sophisticated energy manipulation and renewable power. Once our market place is geared towards delivering energy efficiency and locally generated power – so that business is rewarded for the quality of energy service rather than the sheer quantity of fuel it sells – then the power of the market place will be focused on providing these solutions. The development of sustainability solutions will be a long-term process of continuous refinement and development of our technologies, institutions and governance structures.

This understanding of sustainable energy as a dynamic evolving process of innovation and change contrasts substantially with the more traditional static approach to policy-making which focuses on the present structure and technologies (which have developed under the market and government failures[77] that characterise our current energy system) when determining future prospects for energy. However, if society requires perfect information (with no technical, economic, social or environmental uncertainties) before undertaking policy decisions then we will fail to create the environment in which the development of sustainable energy solutions will be encouraged. This energy vision looks beyond the present standing of our technologies, institutions and market place structure and recognises that a reoriented market can provide incentives for dynamic development in technological and system improvements. The key challenge presented by this sustainable energy vision is that of bringing to reality the great potential for vastly improving our efficiency of energy use, and the renewable energy technologies.

At the same time this 2050 vision is the start of the process in making it a reality. It illustrates what could be possible if we put our minds to it, and it provides a target for an energy transition, and for guiding strategic energy policy. With climate change pressing we need clear leadership in outlining our programme for redirecting our energy system. Although still confronted with a number of uncertainties and unknowns we nevertheless know enough to transform our production and use of energy along sustainable lines. There is no time to procrastinate about the best way forward when the need for action is so pressing and the opportunities for change are so clear.

5.5 Improving Economic Performance through Energy Efficiency

This vision is characterised by radical improvements in energy performance and manipulation. The potential for increasing the productivity of energy use across all applications in all sectors is huge. However, although energy efficiency improvements lead to financial savings more often than not these opportunities go begging. Efficiency improvements are also difficult to target with government policy. Quite simply most companies and consumers just do not apply much thought

[77] The definition of market and government failure is presented in the Glossary

to energy management or to the efficiency rating of their products and buildings. Cost effective efficiency gains are also available to commercial and public bodies. A number of different studies have illustrated that cost effective energy efficiency improvements often accounting for up to a third of overall energy consumption are available to the commercial, public and domestic sectors.[78] Why have these organisations failed to reap these benefits when their energy usage and costs are often very large? If there are economic benefits to improved energy management and efficiency, then why are these potential gains not taken advantage of?

The main reason for the failure to reap these benefits is simply that energy consumption and management is not a priority issue. Most people do not ever think about it or are unaware about the energy and financial savings that they could make. Many of those of have heard about energy efficiency consider themselves to be too busy to be concerned about it or simply do not get around to it. This is even the case for businesses that could save a great deal of money if they bothered to look into the issue. This problem may be described as informational failure – in that the market fails to deliver energy efficiency benefits because the information about what is possible and available simply fails to get across to the market players. Information is also lacking for consumers or businesses who may investigate the opportunities available to them. An erroneous attitude also prevails that activities which benefit the environment, such as energy efficiency improvements, have a financial cost.

Lack of information is not the only market failure responsible for inefficient energy use. The market price of fuels and electricity are lower than the optimum economic price because of environmental externalities of fossil fuel use. Fossil fuel supply has historically also been heavily subsidised by government whereas efficiency has not[79] (other than through a small number of government projects targeting energy efficiency in low income groups) – this weights the market towards inefficient fuel

[78]Association for Energy Conservation (ACE) 1997 *A Realistic Strategy for Reducing Greenhouse Gas Emissions in the Period 2000-2010 using Improvements in Energy End-Use Efficiency*;
Energy Saving Trust (EST) 1997, *Energy Efficiency and Environmental Benefits to 2010;* and,
Shorrock, L. D 1995, *Potential Carbon Savings from Energy Efficiency in Housing,* BRE Information Paper.

[79] The very large direct subsidies for fossil fuels have been significantly reduced since 1995, however, the low rate of VAT on domestic fuel has outweighed the subsidies for energy efficiency projects throughout the 1990s.

use as opposed to efficient fuel use. The financial return on investment in efficiency measures also tends to take a number of years (although this often is not the case for business energy management) such that consumers and companies do not look favourably on undertaking the investment. The large amount of rental in the commercial building market means that the building users are not able to make improvements and the owners have little incentive to do so because they do not pay the bill. The very worst efficiency standards in domestic buildings tend to be found in the rental sector where the owner has no incentive or interest in improving efficiency.

These institutional and market barriers to improved energy efficiency are responsible for misleading some analysts into believing that energy efficiency improvements are expensive and will "cost" the economy. However, it is clear that these efficiency gains have not been reaped due to market and policy failures and not due to high economic costs. The present market distortions and failures are leading to inefficient use of energy and the failure to take cost-effective efficiency improvements that could save the economy as a whole many millions of pounds[80]. The challenge for policy makers to make this vision a reality is to address these market failures and stimulate growth in dynamic energy efficiency markets. Some ideas for how to do this are outlined in the energy vision above.

[80] See Factor Four – Doubling Wealth, Halving Resource Use

6 PROGRESS TOWARDS THIS VISION - RECENT TECHNOLOGICAL AND MARKET DEVELOPMENTS

6.1 The Low Carbon Economy – A Recognised Business Opportunity

The increased level of understanding of climate change in society and business over the last ten years and the focus provided by the Kyoto target has lead to a growing proportion of the business world recognising that future competition and market opportunities will reside in a low carbon economy. The CBI, and other business and industry trade associations, acknowledge the threat of climate change and the need to reduce carbon dioxide emissions. The fossil fuel based energy industries – including transport and electricity generation oriented industry - also acknowledge the need to reduce carbon dioxide emissions. Business leaders across industry have to varying degrees adopted the climate change rhetoric outlining the need for a transition to a low carbon economy, and government legislation such as renewable energy policy and the climate change levy is focusing business' mind upon its use of fuels and electricity. Although this has not yet had a large impact upon the energy management practices of business as a whole it is creating market opportunities for innovative companies, particularly when combined with other market opportunities, such as the liberalised electricity market-place.

A new type of energy industry is beginning to emerge that covers many of the aspects of this sustainable energy vision. Companies already exist that provide technologies and services for highly intricate heat and electricity management in buildings, highly efficient renewable electricity generation and the development of solutions for micropower systems and decentralised electricity generation. Taken together these industry changes could represent the early foundations of the 2050 sustainable energy vision presented in this document.

6.2 Progress Towards a Decentralised Electricity System

The electricity market place has changed substantially since the liberalisation process began in the late 1980s. The creation of a market place has introduced dynamism to the electricity industry which has forced the energy utilities (electricity generators and suppliers) to adjust to competition and constant change. This is

stimulating technological development and, as the focus increases on carbon dioxide reductions, challenges the overall hegemony of the centralised electricity system.[81]

The big players in the electricity market are beginning to invest in the type of technologies that could deliver a decentralised electricity system. Large companies such as BP and ABB have re-launched themselves as companies that recognise the need for change in our energy system and who wish to be at the forefront of developing solutions that deliver sustainable energy. BP has re-launched itself under the banner of "Beyond Petroleum" and has stated that it wants to be a leader in the transition to a far more energy efficient and renewably powered future. BP and Shell both have large renewable energy and fuel cell sections to their business. Shell Hydrogen (a new Shell company) aims to explore the opportunities of fuel cells and the hydrogen economy. ABB (one of the world's largest energy infrastructure construction and engineering companies) has decided to move out of the large power station business to concentrate on micropower and individual site-level energy solutions. It believes that this is the future and has therefore completely changed its business area and knowledge and skills base. It is concentrating on improving its ability to manage the complexities associated with decentralised electricity generation and improved "electricity management". Other large companies are also moving into the micropower and energy management area, and businesses that formerly operated exclusively in large-scale centralised electricity generation are now beginning to branch out into the building and managing of micropower (in the form of CHP) systems for individual premises. Numerous other examples exist of power companies that are redirecting their research and skills base towards decentralised generation and use.

Electricity generator and distributor, TXU, has introduced the "SolarNet" in the UK which is a net-metering scheme whereby TXU will purchase electricity from a customer at the same price as the company sells electricity to the customer. Micro-CHP units aimed at the domestic market are already available – if a little expensive.

[81] The growth in decentralised electricity generation, and the changing face of the electricity industry, has been widely documented in the energy and mainstream media over the past year or so. See, for

The Department of Trade and Industry convened an Embedded Generation Working Group to analyse the current technological and institutional configuration of the national grid and the barriers that it presents to the growth in decentralised electricity generation. The Group's report provides a fundamental re-assessment of the way that the UK national grid and distribution networks currently operate, and its detailed recommendations outline measures for enabling decentralised generation to be "treated" on an equal basis with centralised generation. It also provides a longer-term vision of the electricity system whereby regulatory and market incentives reward good performance rather than simply the volume of electricity flowing through the wires. This assessment of our current centralised electricity distribution system and the clear recommendations for improving its design (in terms of the regulatory driven incentives) for decentralised power is extremely positive for the future development of a decentralised electricity system.

There are a large number of specialist smaller companies which already offer energy management services and technologies for business. The climate change levy will provide a huge boost for these companies. Growing numbers of businesses are opting to generate their own heat and power rather than rely upon the national grid, and the micropower industry is expanding to accommodate this.

6.3 Fuel Cell Developments

All the major car manufacturers have invested significantly in fuel cell research and development over the past ten years leading to improvements in fuel cell power output of almost ten fold. Fuel cell vehicles are now expected to be commercially available before 2005.Bill Ford, the Managing Director of Ford International has stated that, "In 25 years fuel cells could be the predominant automotive power source, and fuel cells could end the 100-year reign of the internal combustion engine[82]."

6.4 Renewable Energy Developments

example, the prominent articles on "micropower" in The Economist, August 2000, and The Financial Times, September 4th, 2000.

[82] From *On the Road to a Hydrogen Economy,* ENDS Report 311, December 2000

Wind power has developed significantly over the past decade so that it is now competitive with fossil fuel electricity generation. Offshore wind is already in operation in Danish waters, and there are two turbines off the Northumberland coast. The development of the wind power industry in Denmark has been highly lucrative with significant economic and employment benefits. Energy crops and biomass is beginning to develop in the UK with a number of biomass power stations under construction in England and Wales. Energy from biomass is already extremely well established in other European countries – for example it supplies a significant proportion of Austria and Sweden's energy needs. A wave power station was recently completed on the Isle of Islay and now supplies the local network.

Photovoltaics (PV) are becoming well established in developing world countries where sun levels are high and the centralised electricity system is weak and fragmented. PV is also benefiting from government support in a number of European in countries, such as Germany which has a programme to deliver 100,000 PV roofs. Although PV is currently very expensive, there is potential for reducing the price of PV cells once economies of scale have been achieved in manufacture, and for reducing the cost of PV cladding once it is incorporated as a construction industry cladding material.

6.5 Improvements in Building Energy Performance and Heat Management

Over the past seven years the Energy Saving Trust has, with relatively few resources, enabled significant improvements in the energy performance of a large quantity of social housing. Although the resources allocated towards improving the energy performance of the housing stock have been quite limited (£150 million) they have had a powerful economic impact by enabling life-time fuel savings that are approximately four times higher than the investment costs of delivering the efficiency improvement schemes[83]. With an increased emphasis on improving the energy performance of the building stock it would be possible to deliver energy savings amounting to a significant percentage reduction in domestic energy use whilst also delivering substantial longer-term economic benefits.

[83] *Energy efficiency Commitment Report* 1999-2000, Energy Saving Trust 2000

As outlined above there are many small companies providing heat and electricity management technologies and services. Although these services are currently targeted at the business and public sectors (i.e. fairly large users), there is no reason why they should not penetrate the domestic sector in the future.

6.6 Ultra Efficient Building Developments

The Beddington Zero Energy Development (BedZED) currently under construction in south London is a low energy housing and office development with a biomass fuelled CHP unit. The homes will benefit from passive solar energy and high efficiency so that their heating requirement will be only 10% of that of a conventional home. The BedZED homes have proven very popular and all eighty are already accounted for. BedZED was brought about through a partnership between the local authority, a large housing association, and an environmental NGO. BedZED is a good example of how imaginative partnership work can bring this sort of development to fruition. The BedZED homes join a select few of ultra efficient homes found across the country (less than 100), but nevertheless demonstrates that such housing can be built at reasonable cost, through imaginative partnerships and with a successful and popular outcome.

The Queen's Building, De Montford University was opened in 1993. It requires 25 – 50% of the fuel of conventional office buildings but was built on a fairly low budget. It is naturally ventilated, saving on large air conditioning costs (financial and energetic) and makes maximum use of natural light and passive solar heating.

7 THE ROLE OF THE ENVIRONMENT AGENCY IN SUSTAINABLE ENERGY

7.1 Sustainable Development – A Learning Process

As is stated in Government guidance, the primary duty of the Environment Agency is to contribute to sustainable development through the delivery of its statutory duties and functions. It is clear that the regulatory duties that the Agency has inherited from its predecessor bodies cannot by themselves solve the environmental problems that the UK faces (the Agency has no powers to address a number of key economic sectors, it has only limited powers to influence those sectors that it does actually regulate and it has very limited influence over the UK's environmental footprint abroad). The roots of these problems lie deep within the workings of our current economic and societal systems, and the concept of sustainable development has arisen as a response to this situation.

Brundtland's is the mostly widely used definition of sustainable development; "development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). However, this is a very broad, unspecific definition that leaves the main issues unresolved; namely, what are people's needs and how do we satisfy these without undermining our environment. These are issues that need to be resolved as the sustainable development process takes place. Nevertheless, it is clear that sustainable development is about change – it is about changing our model of development – and it will be a learning process because society has yet to decide exactly what its needs are, and how to deliver its services sustainably.

Sustainable development will require trial and error and will incorporate technological, institutional and cultural change. As Burgess et al (1999)[84] puts it, *"..sustainable development will remain a contested question that will continue to engage firmly with cultural and political issues in reaching judgements about the environment"*. For this reason sustainable development is (and will continue to be) an inherently political process. Sustainability issues go to the heart of all decision-

making in central and local government and in business and will require debate and arguments as to the best solutions.

And above all the sustainable development process will require commitment to the sustainability cause. This is recognised by Burgess et al (1999), "*Fundamentally, sustainable development is about a change in values, and in particular the promotion of a set of values that raises the status of the environment when seeking to balance social, economic and environmental aspects of decision making*". This demonstrates a clear role for the Environment Agency in promoting sustainability thinking and the interests of the environment at all levels of decision making in the UK. This is particularly important because sustainable development will require changes (in industry and all other economic sectors) and any change needs to overcome inertia and vested interests.

As sustainable development is an inherently political process in order to maximise its impact the Agency should be active in the sustainable development debate. In order to take forward sustainable energy in the UK we need to develop consensus over the long-term goal for energy policy and over what constitutes sustainable energy. Once consensus has been reached all organisations, including the Agency, can play their part in the process of achieving sustainable energy.

7.2 The Agency and Sustainable Energy

Energy is an important issue for the Agency – and not just because it is a key aspect of sustainable development. The regulatory work of the Environment Agency touches upon various aspects of energy production and use in England and Wales, and climate change will have significant implications for flood risk and water resources management in England and Wales. The recent flooding problems have focused the minds of the country at large, and particularly the Agency, on the increased flood risks that climate change will bring and the need to do all we can to reduce greenhouse gas emissions in order to limit the extent of climate change and its impacts. The Agency regulates power station emissions, nuclear waste disposal and oil refineries. It also recently acquired the duty to consider the efficiency of

[84] *An Analytical and Descriptive Model of Sustainable Development for the Environment Agency,*

energy use by all industries it regulates. However, these regulatory duties only cover certain aspects of our energy system, and in delivering these duties the Agency has not the ability to strongly influence the main direction of energy practices in the UK. Therefore, in order for the Agency to more fully influence the UK's energy systems, and the transition to sustainable energy, it will need to adopt more of an influencing and advocacy role, and prioritise which aspects of energy it has the greatest scope to target and which are the most important in sustainability terms. The Agency will only be able to do this by developing its position on sustainable energy - so that it knows what energy practices it wishes to promote.

The Agency regulates electricity generation in line with pollution control legislation, mainly in EPA 1990. Could the Agency do more to influence the long-term direction of the electricity industry? Should the Agency work with the electricity industry to develop a sustainable electricity vision and then aim to move in this direction? As this 2050 vision demonstrates, the electricity industry has the potential to change significantly over the coming few decades, and the generation and use of electricity could become far more localised, whilst the number of large scale generating sites could decline. Significant changes could also occur in the nature of large-scale generation - should the Agency begin encouraging generators to invest in offshore wind farms rather than conventional generation capacity?

Under IPPC the Agency has acquired the duty to have regard to the energy efficiency of the processes that it regulates. However, the Climate Change Levy and Negotiated Agreements, and the Carbon Trading Scheme, represent the main policy targeted at business and industry energy use, and will restrict the scope of the Agency's implementation of its energy efficiency duty. Nevertheless, the prospects for improving energy productivity can go well beyond simply a narrow focus on the energy efficiency of a very specific process. The Agency could seek to complement this tool with efforts to encourage industry to adopt other sustainable energy practices, such as CHP or the use of gas rather than coal as a primary fuel source, and to help stimulate the development of radical resource and energy productivity in

industry. The Agency could also try to influence the energy practices of those it regulates through other, more informal, means.

The Agency could maximise its contribution to the development of energy efficiency schemes and renewable energy sources through working in partnership at the local, regional and national level. Sustainable energy covers a very wide range of issues, and, although it is a large organisation, the Agency will fail to have much of an impact if it targets issues in isolation – the Agency will need to work collaboratively to maximise its impact.

The Agency addresses its own energy consumption through its internal environmental management programme. The Agency could concentrate on demonstrating best practice and leading the way in energy efficiency, combined heat and power and local renewable energy exploitation.

Appendix 1 of the Sustainable Energy Vision – Glossary of Energy Terms and Technologies (as used in this vision)

Decentralised generation, also referred to as **distributed generation** or **micropower** (and can also be known as **inter-connected** or **local power systems),** refers to smaller-scale electricity generation which does not rely upon the high voltage national grid for transmission. It is small-scale in comparison to the large power stations upon which our current electricity system is based. **Embedded generation** refers to commercial power produced for the local distribution networks, whereas conventional big power generation is fed into the high voltage national grid. Micropower can also consist of very small on-site generation for own consumption, which is only sold to the local distribution network when it is not needed by the owner.

Energy efficiency (or energy productivity) when used in general terms refers to the whole array of opportunities for using energy more effectively so that it delivers greater productivity (in terms of the benefits it brings society) per unit of fuel or electricity that is used. It is probably better described as improved **energy performance** because it includes better management and the use of ambient energy – which is not related to any conversion efficiency. These improvements include:

- improvements in conversion efficiencies from fuel to electricity or/ and heat;
- improvements in the efficiency in the operation of electrical goods or industrial processes;
- improvements in the thermal effectiveness of buildings;
- improved energy management, such as lighting and commercial/ industrial processes; and,
- economy-wide efficiency improvements arising from waste minimisation, increases in industrial resource and energy productivity (from new processes and technologies) and societal changes resulting from new technologies, such as telecoms.

Thus, an energy efficient (high energy performance society goes well beyond simply installing fluorescent light bulbs in all buildings (although this would make a substantial impact on electricity use). It involves far reaching changes in all aspects

of our energy system. This vision aims to provide an insight into the vast array of opportunities for undertaking these productivity improvements.

The UK **energy system** consists of the entire infrastructure that delivers the energy services that we require, including buildings, electrical appliances, transport systems, the production, delivery and combustion of fuels and the generation and distribution of electricity. Delivering sustainable energy will require changes in all aspects of our energy system so as to maximise the efficiency with which we use fuels and electricity. The emphasis of the energy service delivery could shift to the energy hardware rather than the supply of fuel, and to the exploitation of renewable energy.

Although they are not yet a part of the general public consciousness **fuel cells** will become a mainstream technology over the next ten to fifteen years and are predicted to completely replace internal combustion engines in the longer term. However, fuel cells have the potential to cover almost all energy applications because they can produce both electricity and heat from their hydrogen fuel. The fuel cell relies upon an electrochemical reaction between hydrogen and oxygen to produce electricity (and/ or heat) and water as a waste product. The electrochemical process in the fuel cell is an inherently more efficient conversion process (up to 80% efficient - excluding the reformation process) than thermal combustion (internal combustion engines are 20 – 25% efficient and combined cycle gas turbines are 40 – 45% efficient).

As hydrogen gas is not at the moment readily available the fuel cell requires a reformer to make hydrogen from another fuel, such as natural gas or petrol. Nevertheless fuel cell cars are still more efficient and cleaner than modern conventionally powered cars even though the reformer is required as an addition to the vehicle. In the longer-term this efficiency can be significantly increased if hydrogen becomes widely available, particularly from renewable energy sources, and the reforming equipment is no longer required. In a fuel cell car the electricity generated by the fuel cell is used to power an electric motor which drives the vehicle forward. Fuel cells also provide almost 100% reliable electricity (in terms of the constancy of the current) and therefore are likely to be very popular with large-scale computer users because IT equipment requires quality current. The national grid is not able to guarantee this level of reliability.

Government failure refers to government policies that distort the market place, and thereby contribute to the inefficient allocation of resources, or exacerbate existing market failures. For example, subsidising fossil fuel use distorts the market place towards excessive (& inefficient) use of fossil fuels and also exacerbates the existing externality of atmospheric pollution (see Market Failure below).

Heat Pumps represent a highly efficient way of generating heat from electricity – they deliver heat energy 2 to 4 times the rate of electrical energy they use. Conventional methods of electric heating for buildings provide a third of the quantity of heat for the amount of electricity used than do heat pumps. Heat pumps operate in exactly the same way as a refrigerator. They use a refrigerant liquid that boils at low temperatures and takes in heat energy as it evaporates. This process takes place outside the building. The heat pump then feeds the gas through pipes to the inside of the building where it is compressed into liquid form (which is the electrical energy input to the heat pump). In changing into a liquid the chemical releases the heat energy that it took up when it evaporated. This processes goes on continually so that the heat pump transfers a lot of heat into the building and warms it up. Although there exists a small industrial use of heat pumps they have had little impact on the commercial or domestic sector.

The **hydrogen economy** is often presented as a solution for dealing with the technical challenges presented by a renewable energy powered future. It would involve the use of hydrogen as an energy carrier which could store and deliver the energy obtained from renewables. Essentially the hydrogen economy represents a way of converting the energy flows of the intermittent renewables into a fuel so that it can be stored and used when and where it is needed. The hydrogen economy would be a symbiotic relationship between renewables and fuel cells and would utilise hydrogen as the societal energy carrier (replacing the role of fossil fuels, and even perhaps electricity transmission). Renewably generated electricity could be used, through the electrolysis of water, to produce hydrogen. Hydrogen could then power fuel cells in industry, transport and our homes so as to generate electricity and heat for all our energy service requirements.

Market failure is an economic term that refers to the failure of the market place to ensure an optimal allocation of resources. Economic theory dictates that the perfectly functioning market place will, through the medium of prices, deliver the optimum outcome for society by balancing, amongst other things, the wishes of consumers with the cost of resources to deliver consumer goods and services. However, this rarely happens because the perfectly functioning market rarely (if ever) exists. The term market failure is used to describe this failure in the functioning of the market place to achieve the economic optimum (i.e. the best creation of wealth for society as a whole), and in the environmental context normally refers to externalities and informational failures. The main externality in the energy sector is the failure of the market to capture the resource costs of carbon dioxide emissions (i.e. the greenhouse effect and climate change) in the price of fossil fuels. This important cost associated with the use of fossil fuels is not captured in their price – i.e. is external to the workings of the market. Fiscal measures, such as a carbon tax, and legislative measures, such as mandatory energy efficiency information provision, can help reduce these market failures and harness the power of the market to achieve the optimum economic outcome for society.

The **regenerative fuel cell** is an energy storage technology which locks up electricity as chemical energy – and then instantly generates electricity when it is needed. This storage technology has a high energy density. One energy utility is about to construct a large regenerative fuel cell installation that will have a 15MW power output (the same as a sizeable wind farm) and will feed directly into the distribution grid. They believe that this storage capacity will bring them many benefits. A number of other novel **energy storage technologies** are in their research and development phase. These include flywheel energy storage and superconducting magnetic energy storage.

Appendix 2 of the Sustainable Energy Vision – The Inefficiency of UK Housing and Electricity Use and Current Potential for Improvement

Inefficient Buildings

In our present energy system low temperature heating is the single largest component of UK fuel demand by end-use, accounting for 36% of end use energy consumption[85]. In the year 2000 fuels and electricity for heating represent by far the largest component of energy use in the domestic, commercial and industrial sectors. However, the opportunities for improving heat management, and the use of ambient solar energy, in buildings are vast. Although the technological know-how exists and there are a number of individually built energy efficient houses in the UK, the UK construction companies resist the industry changes that would be needed in order to build energy efficient houses as standard.[86]

The UK building stock is amongst the most energy inefficient of any country in Europe. Our buildings are particularly put to shame by the energy standard of buildings in Scandinavia, which although it has a much colder climate than the UK, requires less fuel to heat its houses. Indeed, although all new housing constructed in the UK since 1995 conform to energy efficiency standards that are twice as efficient as the average existing UK house before that date, new houses built in Scandinavia are still two to three times as efficient as new houses built here.

The replacement rate of new houses for old is presently very slow at about 0.1% per year. At this rate of replacement it would take well over a century for newly built efficient buildings to outnumber the older inefficient ones. Although the replacement rate of post 1950s housing is likely to increase over the next few decades, existing buildings are still likely to form the majority of our building stock for at least the next century.

Electricity Use

[85] Figures obtained from *Energy – The Changing Climate,* the twenty-second report of the Royal Commission on Environmental Pollution.

[86] See Olivier, D. & Willoughby, J. (1996), *Review of Ultra-Low-Energy Homes, Report 38,* Energy Efficiency Best Practice Programme report

Although only approximately one-sixth of overall end-use consumption of energy is in the form of electricity, because of the inefficiency of generation and transmission almost one-third of primary energy inputs are devoted to electricity generation. Approximately a third of electricity generation is from large coal power stations (although this capacity declined throughout the 1990s and is likely to continue to decline over the next decade and beyond) which are highly inefficient converting about 30 – 35% of the energy content of the coal into electricity. The rest of the energy content is wasted as low-grade heat. However, the recent expansion of natural gas generated electricity, which now supplies over the third of UK electricity, has improved the thermal efficiency of electricity generation. This is particularly due to the large number of combined cycle gas turbines which are approximately 45% efficient. There are further losses in the transmission of electricity around the national grid which account for 10%? of the electricity generated. These two types of energy loss can be reduced through increased use of combined heat and power and more locally generated electricity respectively.

Electrical products already exist in 2001 that are substantially more energy efficient than the average product available at the market place, which are even more efficient again than the average product in use in homes and offices across the UK. If domestic energy efficiency improvements were treated as a priority issue in government policy these products could dominate the market place by 2005. This includes refrigerators that use approximately 20% of the electricity of the majority available in 2001 (which in turn consume 50% less electricity than those that are 10 years older and dominate the working stock), and televisions, VCRs and washing machines that consume approximately 30% less electricity than the average model available for purchase in 2001.[87] Office equipment is also very inefficient in 2001, such that it is already possible to reduce office electricity use by up to 65% through the adoption of energy efficient equipment and good management practices[88]. These high efficiency products are available even though manufacturers have faced very little incentive to improve the energy efficient of their goods (due to low energy prices and lack of consumer interest in the energy efficiency of appliances). The scope for further improvements in the energy efficiency of products over the next

[87] Data taken from the Market Transformation Programme supporting material (a DETR website).

fifty years looks very healthy indeed when we consider that the market distortions will be removed so that a primary focus of market competition is steered towards energy efficiency. Coupled with the historic general trend of increasing efficiency levels and of continued available efficiency gains, this market and legislative driver provides for a strong expectation of increased efficiency levels in this 2050 vision. As the Royal Commission on Environmental Pollution commented in their assessment of energy efficiency potential, "It seems a curious feature of energy efficiency studies that they seem regularly to identify cost-effective potentials of around 20-30% of current demand, almost irrespective of the potential already exploited."

[88] Data taken from the Market Transformation Programme supporting material (a DETR website).

APPENDIX 2 – ENVIRONMENT AGENCY RENEWABLE ENERGY POLICY POSITION

1 INTRODUCTION

1.1 This position paper sets out the Agency's opinions and stance on renewable energy. Clearly, renewable energy has a vitally important role to play in reducing greenhouse gas emissions and other air pollutants, and in providing a sustainable long-term energy source as a replacement for the finite fossil fuels. Nevertheless, renewable energy in the UK is still a fledgling and vulnerable industry, and opinions are diverse on the exact role of renewable energy in delivering wider sustainable energy objectives. Many are concerned about the potential environmental impacts of renewable energy.

1.2 Renewable energy presently contributes approximately 3% of UK electricity. The Government target is to deliver 10% of UK electricity from renewable sources by 2010. Its main policy measure for delivering this target is the Renewables Obligation on electricity suppliers. Renewable energy is also exempt from the climate change levy and Government is providing almost £200 million in capital grants and other support towards the development of renewable energy technologies.

1.3 However, there are a number of barriers to the development of renewable energy in the UK. The institutional and market arrangements of the electricity system do not favour renewable energy, and the Embedded Generation Working Group recently made a number of recommendations for addressing this. In addition to this, the New Electricity Trading Arrangements (NETA) which commenced in March 2001 have already been shown to have an adverse effect on the financial value of renewably generated electricity[89].

[89] See Graeme Bathurst and Goran Strbac, April 2001, *The Value of Intermittent Renewable Sources in the First Week of NETA*, Tyndall Climate Change Centre – Position Paper

1.4 Planning objections to renewable energy development proposals are another key obstacle. These objections are often argued on environmental grounds, and the perceived visual impact of onshore wind farms is probably the main barrier to their future development.

2 THE AGENCY AND RENEWABLE ENERGY

2.1 Across England and Wales the Agency is a key partner in the regional renewable energy assessments, the establishment of regional targets and regional strategies for progressing renewable energy. The Agency has also contributed to the national renewable energy policy development process, and the role this has within the climate change programme and the wider sustainable energy context.

2.2 The Agency is also a consultee for renewable energy planning enquiries. In addition the Agency has a specific role in the development of small-scale hydropower projects for which developers require a range of Agency permits. The Agency is also the competent authority for permits under the IPC and IPPC regimes for large thermal combustion activities, which can include biomass as well as fossil fuel.

2.3 The Agency's Environmental Vision highlights energy as a key sustainability issue, and outlines the Agency's desire to work with partners to contribute to the development of renewable and sustainable energy in the UK.

2.4 The role of renewable energy within the wider sustainable energy context is of great significance to the Agency. Climate change will have substantial implications for the flood defence and water resource management duties of the Agency. The Agency is also responsible for regulating many aspects of fossil fuel use and for regulating nuclear waste. The Agency is keen to position these activities within its wider understanding of sustainable energy and its contribution to the outcomes in its Environmental Vision.

2.5 This renewable energy position outlines the Agency's general positioning on renewable energy and will be supported in the future by specific guidance on each of the individual renewable energy sources.

THE ENVIRONMENT AGENCY'S RENEWABLE ENERGY POSITION

1. **The Agency believes that alongside significant improvements in energy efficiency, renewable energy has a vital role to play in improving the sustainability of the UK energy system.**

2. **The Agency believes that renewable energy has the potential to provide truly sustainable energy for UK society, and that through a well managed approach to the expansion of renewable energy that ensures the sensitive siting and operation of renewable energy schemes, potential negative sustainability implications can be avoided. The Agency considers fossil fuels and nuclear power to present fundamental sustainability problems, whereas the sustainability impacts of renewable energy tend to be more local in nature and can be more readily ameliorated or controlled.**

3. **The Agency is generally supportive of all renewables (onshore and offshore wind, solar, energy crops, agricultural & forestry wastes, wave, tidal stream, geothermal and small-scale hydropower[90]) but we believe that the environmental detriment associated with new large-scale hydropower schemes and tidal barrages is likely to be unacceptable in most cases.**

4. **The Agency does not consider the majority of energy recovered from municipal waste incineration to be within the definition of a viable long-term renewable energy source. Much of the energy content of mixed waste is from non-renewable resources, such as plastic. In addition policies aimed at minimising waste arisings and increasing recycling rates will mean that waste incineration is likely to decline in the long-term. We believe that the**

[90] The Agency has a specific policy for small-scale hydropower – please see bullet point 22.

treatment of the "renewable" component of energy (derived from the biodgradeable portion of the mixed waste) should not undermine the achievement of waste prevention and recycling targets. Nevertheless, energy from waste will still have a role to play in electricity generation in the short to medium term and waste incineration will remain a viable component of future BPEO based waste management strategies.

5. **Similarly, although landfill gas mainly arises from the decomposition of putrescible waste, which is arguably a renewable resource, the landfilling of this waste should substantially decline in the near future with the introduction of the Landfill Directive and the adoption of more sustainable waste management practices. For this reason landfill gas should not be considered a long-term renewable energy source. Nevertheless, the Agency promotes the energy capture of landfill gas on extant landfill sites due to the substantial environmental benefits that this brings.**

6. **The Agency supports the Government's target to supply 10% of UK electricity from renewable sources by 2010 and recognises the important role that renewable energy can play in reducing carbon dioxide emissions in both the short and the long term. We believe that government should also establish a renewable heat target as a means of addressing the substantial carbon dioxide emissions associated with space heating. We believe that wherever possible biomass should fuel combined heat and power generation. We also recommend that government sets a target for micro-renewables, such as photovoltaics and on-site biomass combined heat and power.**

7. **The Agency believes that Government should also establish longer-term renewable energy targets that clearly communicate the long-term objectives for the electricity and heating-fuel markets[91].**

[91] The Agency supports the recommendation of the Environment, Transport and Regional Affairs Committee that there should be a longer-term target for 50% of electricity to be supplied by renewables by 2030.

8. **The Agency believes that, against the back-drop of expected reductions in electricity prices, the estimated cost to consumers of meeting the 10% renewable electricity target is perfectly reasonable and should not be allowed to interfere with the achievement of the target[92].**

9. **The Agency is concerned by the low installation rate of renewable energy over recent years and recognises that the annual rate of installing renewables capacity will need to increase by sevenfold[93] in order to meet the 10% renewable electricity target.**

10. **The Agency believes that the expansion of renewable energy needs to be better managed, particularly in planning for renewables, so as to enable the successful and sustainable growth of renewable energy in the UK, and enable the present conflicts to be resolved. The Agency recommends a two tier approach; the involvement of all stakeholders in developing regional and local renewable energy development plans across the UK, and the careful siting of specific renewable energy schemes including a detailed sustainability assessment to determine their environmental and social implications.**

11. **All renewable energy developments should follow best practice so that environmental impacts are eliminated or reduced to a minimum. Best practice guidance for all the different renewable energy technologies should be clearly available to developers. This guidance could also provide a structure for the sustainability assessment of specific schemes.**

12. **The Agency recognises, and supports, the government's efforts to improve the overall approach to renewable energy development, such as the requirement for regional targets for renewable energy, but we believe that more needs to be done.**

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[92] See *The Environment Agency's Response to the DTI Consultation on the Renewable Energy Obligation*, November 2000.

13. The Agency recommends the creation of regional renewable energy development bodies to stimulate and oversee the sustainable expansion of renewable energy across the UK. These bodies can ensure that there is a well resourced and coordinated approach to the planning and development process for renewable energy in each region.

14. The Agency recognises that wind power, energy crops and agricultural and forestry wastes will be the most important renewables[94] for achieving the 10% target as these are the most developed renewable energy technologies. The other renewables are expected to be able to play only a small role in achieving the 2010 target, and their role will grow after 2010.

15. The Agency is therefore supportive of onshore and offshore wind, energy crops and agricultural and forestry waste in terms of their contribution to the 10% target. The Agency believes that, with sensitive siting and management, these sources have significant resource potential for delivering the 10% target, and for contributing to much larger targets in the future.[95]

16. The Agency considers renewable energy to be a massive new industrial market and the Government should ensure that UK business is able to grasp this opportunity. Renewable energy developments can bring economic and social opportunities to local areas and regions, and can contribute to rural development and diversification.

17. The Agency promotes the locally appropriate choice of location for renewable energy schemes. The Agency supports good sustainability practice in renewable energy developments, such as public participation through all stages of development (including the setting of regional and local

[93] From the House of Lords Select Committee on the European Communities report on Electricity From Renewables, June 1999.

[94] Out of those renewables which satisfy the definition of renewable energy adopted by the Agency, and those renewables supported by the Agency.

[95] For example, the onshore wind resource is estimated to be very large (more than 100% of the present UK electricity demand, excluding all National Parks, SSSI, NNR etc, all urban areas, forested land, and lakes and rivers, and all lower wind speed sites) which leaves significant scope for sustainable utilisation.

renewable energy targets), development on brown field sites, and development of renewable energy in all regions of the UK (and not just the very highest wind sites[96] etc). The Agency will produce environmental best practice guidance for renewable energy technologies as they relate to Agency responsibilities.

18. **The Agency supports the community ownership of renewable energy schemes where possible. Government should support this by providing guidance on how communities can own or jointly own renewable energy schemes, or even help establish a club for communities involved in schemes. Greater public involvement in renewable energy developments has the double benefit of not only increasing public acceptance of renewable technologies but also helping to reinvigorate local governance.**

19. **The Agency recognises that a locally focussed expansion of renewable energy incorporating good sustainability decision-making and management techniques can therefore make a strong contribution to the environmental, social and economic dimensions of sustainable development. The Agency is keen to play its role in realising this by working with key bodies responsible for renewables development such as the countryside agencies, local authorities, NGOs and community groups.**

20. **The Agency would also like to see more renewable energy demonstration projects, better public information about renewable energy, more investment in renewable energy R&D and more subsidies to support the take-up of on-site micro-renewable energy generation, such micro-wind, photovoltaics and solar heating.**

21. **The Agency welcomes the announcement of financial assistance for offshore wind and energy crops and the government's efforts to develop a coherent consents process for developing offshore renewable energy stations.**

[96] The British Wind Energy Association has produced illustrative regional targets demonstrating how onshore wind energy could supply a quarter of the 10% target, which includes all regions of the UK. They argue that wind energy can be competitive in lower wind speed sites.

However, we feel the Government should also provide more support to the development of less mature technologies that nonetheless have great potential for the future, such as wave and tidal stream power. We also urge Government to implement the recommendations of the Embedded Generation Working Group so that our electricity networks are able to accommodate increasing contributions from renewable energy and CHP.

22. The Agency's Position and Policy on small-scale hydropower reflects the specific role which it has in regulating schemes. Developers require a range of authorisations from the Agency; we will take a positive view of reasonable and well-designed proposals. We will work with developers and others in attempting to agree a viable, sustainable project. However, this requires sites to be chosen carefully, and schemes developed sensitively, in order to prevent unacceptable environmental impacts. The Agency seeks to work constructively with the hydropower industry.

23. Although strongly supportive of renewable energy the Agency will of course always uphold its statutory duties should they be affected by a particular renewable energy development.

SUPPORTING MATERIAL

2.1 The definition of renewable energy adopted by the Agency is, "energy obtained from the continuous repetitive currents of energy occurring in the natural environment, used at the same rate as they are replenished"[97].

2.2 Much of the content of municipal waste is from non-renewable sources, and, in fact, our present waste generation and disposal practices are a good example of unsustainable management of non-renewable materials. For this reason energy recovery from waste incineration should be viewed primarily as a pragmatic waste management option that can be pursued until recycling rates and waste minimisation practices improve.

2.3 The classification of landfill gas is a little more complicated because it mainly arises from the decomposition of putrescible waste which is arguably a renewable resource. However, the landfilling of organic waste will substantially decline in the near future with the introduction of the Landfill Directive and more sustainable waste management practices, and for this reason landfill gas should be considered a declining energy source. Nevertheless, its use as an energy source has a double environmental dividend because it not only converts the methane into a less harmful greenhouse gas (carbon dioxide) but also offsets the carbon dioxide emissions that would have been generated elsewhere if a fossil fuel plant had been used to generate the electricity.

2.4 The Agency believes that the UK's 10% renewable electricity target should be restricted to the truly renewable energy sources as these are the ones that have true potential for powering our energy system in the long-term. It is important to focus substantial investment and development on these technologies today so that they are sufficiently mature in the future to substitute for fossil fuels at the same time as the role of energy from waste and landfill gas is in decline.

2.5 The Agency supports the Government position that there is little scope for new large-scale hydropower schemes. We also believe that it is highly unlikely that a tidal barrage would be environmentally acceptable due to their very large impact upon the ecology of estuarine systems. However, the Agency considers the potential contribution of tidal stream turbines to be very promising and acceptable because this technology has a far smaller environmental impact than barrages.

2.6 As long as good sustainability practice is followed the Agency supports all other renewables, which includes onshore and offshore wind, small-scale hydropower, solar, biomass, agricultural & forestry wastes, wave, tidal stream and geothermal power. With the exception of offshore wind, these are all based upon smaller technologies and structures so their environmental impacts tend to be smaller and more localised than conventional fossil fuel and nuclear electricity generation. However, as offshore wind will be located out at sea its visual impact will be fairly small when viewed from onshore.

2.7 The exploitation of renewable energy involves harvesting the natural energy flows in the environment which are very diffuse compared to the high density of energy contained in fossil fuels. Therefore, the use of renewable energy brings the electricity generating infrastructure closer to the consumer through an increasing number of smaller, local generating units.

2.8 This is in contrast to the traditional centralised electricity system which relies upon a relatively small number of large generating units dotted around the country and which takes electricity production (and its environmental impacts) out of sight and out of mind for most people. The development of renewable energy will force the issue of how and where electricity is being produced and the corresponding environmental and social costs. This issue is magnified by the fact that people today have a higher environmental awareness of the impact of developments than they did in the past. If the

[97] Taken from Boyle, Godfrey (Editor), 1996, *Renewable Energy: Power for a Sustainable Future,*

UK's approach to sustainable energy is well managed, this increased awareness could be harnessed so that it contributes to the development of sustainable energy in the UK – rather than being considered as an obstacle to the expansion of renewable energy.

2.9 For these reasons the environmental impact of renewable energy causing most concern is its visual impact upon the landscape. This is particularly the case for onshore wind turbines which are otherwise essentially environmentally benign in their generating phase. However, this visual impact should be considered alongside the visual intrusion that our electricity system already imposes upon the UK landscape, and in particular the many thousands of pylons that criss-cross our countryside.

2.10 The visual presence of a wind turbine or farm would not necessarily be considered as an environmental impact by everyone. Whether it has a negative aesthetic impact or a positive aesthetic impact is determined according to personal taste. Although a change to the landscape can definitely be classified as an environmental issue, the impact it has upon quality of life and sustainability is difficult to assess because preferences can change on the matter.

2.11 It should also be pointed out that although wind farms affect the appearance of the landscape they do not affect the nature or use of the land unlike many other forms of development. Although personal values are very important in determining sustainability impacts it is difficult to equate aesthetic issues with the fundamental risks that continued fossil fuel use and nuclear power pose to natural systems at the global, regional and local level.

2.12 Clearly, renewable energy technologies do have other environmental impacts. For example, energy crops require fairly large areas of land and agricultural inputs, and the combustion plant emissions need to be controlled. Raw materials are required in the construction of all renewable technologies

and their associated infrastructure, and the manufacture of photovoltaic cells requires rare metals. In addition to this, small-scale hydropower, tidal stream and wave power can have some local wildlife impacts. Offshore wind has the potential to be quite different to other renewables because it could be organised in very large aggregations producing large quantities of power. Nevertheless these would be out at sea so that the visual impact on the seascape would be fairly small when viewed from onshore.

2.13 As outlined above the impacts of renewables[98] tend to be local in nature and they do not have regional or global environmental implications in the same way as fossil fuels. And as their name implies they are also a continuously renewable resource. They leave no enduring pollution or contamination, and present no threat to human health. Upon decommissioning they can be removed from the site with no lasting impact or clean-up requirements (although photovoltaic cells need to be carefully managed due to the presence of toxic substances).

2.14 Clearly, this is not true of fossil fuels or nuclear power, and it is for this reason that renewable energy tends to be equated with sustainable energy. Indeed, a number of studies of the environmental impacts of renewable energy sources have suggested that unlike fossil fuels and nuclear power, renewables pose no fundamental sustainability problems as long as their development is managed sensitively, and framed within general steps towards sustainability in society at large.[99] The challenge facing the UK is one of delivering the great sustainability promise of renewable energy – and, therefore, of developing a well managed approach to the expansion of renewable energy and the sensitive siting and operating of individual schemes.

2.15 The technologies that are likely to be the most important for increasing renewables output over the next ten years are onshore wind, offshore wind

[98] This refers to the renewable energy technologies supported by the Agency – as listed above.

and energy crops. Therefore, resolving the issues that surround the development of these technologies will be very important in terms of the expansion of the UK renewables industry over the next decade.

2.16 In addition, small-scale hydropower will pose significant challenges for the Agency because developers require several different licences from the Agency before they can operate. Although generally promoted as one of the most environmentally benign of the renewables, this technology can have implications for fisheries, ecology, flood defence, water resources management and navigations. The Agency seeks to work constructively with the hydropower industry.

2.17 The 10% renewable electricity target represents a several fold increase in renewable energy output even when taking into account the contribution of large-scale hydropower. The annual rate of renewables capacity installation will need to increase by sevenfold over that achieved in recent years in order to meet the 10% target[100]. The low installation rate over recent years has largely been due to planning objections from pressure groups and local inhabitants to the visual impact of onshore wind farms.

2.18 It is often stated that the decision for the go-ahead of a renewable energy scheme should be determined by an assessment of whether the global environmental (climate change) benefits of the development outweigh the local environmental costs. However, in practice it is extremely difficult to compare these costs and benefits in a meaningful way because they represent entirely different types of environmental impact. Is it possible to compare climate change impacts with local visual impacts? Can we decipher the individual effect of one renewables scheme on reducing climate change impacts?

[99] See for example "Renewables in Power Generation: Towards a Better Environment", ETSU 1998, and "Renewable Energy: A Sustainability Analysis Using The Natural Step", The Natural Step, November 2000.

[100] From the House of Lords Select Committee on the European Communities report on Electricity From Renewables, June 1999.

2.19 There are a number of techniques that attempt to confront this challenge. For example, one approach would be to allocate a monetary value to the climate change benefit of avoided carbon emissions and another value to the local environmental impacts and then compare which is the higher. However, the process of arriving at these values is fraught with substantial uncertainty and disagreement, particularly for the climate change value, such as averted sea and flood defences. Therefore, to expect every individual decision related to a renewable energy proposal to be determined through a process of comparing the global environmental benefits with the local environmental costs does not appear to be a sensible way to proceed.

2.20 The Agency recognises the great potential of renewable energy to provide truly sustainable energy, and the need for a rapid and significant expansion in renewable energy exploitation. The Agency, therefore, believes the most suitable approach is for government to provide an overarching framework that will drive the sustainable expansion of renewable energy in the UK. The process of developing, and planning for, renewable energy, needs to be better managed so that there is full stakeholder involvement and ownership, and a higher success rate for renewable energy scheme proposals. The Agency supports the sustainable expansion of renewable energy which, it believes, incorporates two main features - the full involvement of all stakeholders in developing regional and local renewable energy development plans across the UK, and the careful siting and full sustainability assessment of all individual renewable energy schemes.

2.21 It is important that best practice is followed and the environmental impacts of renewable energy schemes reduced to a minimum. The Agency believes that best practice guidance should be produced for all the different renewable energy technologies and that all developers should follow this guidance. This would also help in the process of evaluating the impact of specific schemes.

2.22 The Agency promotes a considered approach to the sustainable expansion of renewable energy that includes:

- The production of regional and local targets for renewable energy schemes with specific allocations in local authority development plans determined through public consultation and based upon resource capacity assessments;
- Full stakeholder participation throughout all stages of renewable energy developments wherever possible promoting sustainable community development;
- The creation of regional renewable energy development bodies to stimulate and oversee the sustainable expansion of renewable energy in each of the regions;
- More development on brown field sites – industrial and urban areas;
- An environmental and sustainability assessment for all developments;
- Better explanation to the public of the environmental benefits of renewable energy;
- A more even development of renewable energy across the UK, for example, incorporating lower wind sites as well as the highest wind sites;
- Where possible the community ownership, or joint ownership with developers, of renewable energy schemes.

2.23 The Agency recognises that a locally focussed expansion of renewable energy incorporating good sustainability decision-making techniques and those practices listed above can therefore make a strong contribution to the environmental, social and economic dimensions of sustainable development.

Environment Agency

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APPENDIX 3

DISCUSSION PAPER 2: THE ROLE OF THE ENVIRONMENT AGENCY IN SUSTAINABLE ENERGY – THE NEED FOR A POLICY POSITION

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30th May 2000

OVERVIEW

The UK's (and the world's) current dependence on fossil fuels for energy is a primary cause of many environmental problems and is the driving force behind anthropogenic climate change, and for this reason achieving a sustainable energy future will be one of the key challenges within sustainable development. The Agency recognises the importance of achieving sustainable energy but has not strategically considered how it can best maximise its abilities to influence the sustainability of energy practices in the UK.

This paper argues that the Environment Agency will be restricted in its contribution to sustainable energy unless it adopts an energy policy position. The Agency needs an energy position simply because it will be unable to encourage sustainable energy practices and technologies if it does not have its own opinion on what constitutes sustainable energy. This paper identifies three potential ways in which the Agency could contribute to the development of sustainable energy. First it could adopt a sustainable energy advocacy role and actively contribute to the energy debate and the energy policy development process. Secondly it could seek to encourage sustainable energy technologies and practices through its work on the ground. Thirdly it could contribute to research and development into the sustainability of different energy technologies.

Sustainable development is a long-term process involving a transition from today's unsustainable economic and societal system to one that improves quality of life without undermining the environment. Undertaking this transition will necessarily

require a political process of societal negotiation and "sustainability" decision-making. This paper argues that if the Environment Agency is to become a force for sustainability in key sectors such as energy then it needs to fully participate in the negotiation process at the national, regional and local level. It is also quite clear that at all levels there is still a large political battle to be fought – in that the commitment to sustainable development is not the foremost concern of the majority of people and organisations working in energy, and other economic sectors. In order to show leadership for sustainable development in the UK the Agency will need to develop opinions on key sustainability issues, such as energy. This will enable the Agency to become an advocate for sustainability thinking and practices throughout society and industry. This approach would also be consistent with the principles and new direction outlined in the Agency's Environmental Vision. Therefore, the Environment Agency will be severely restricting its ability to act as a catalyst for change in society if it seeks to avoid involvement in the "political" issues that lie at the heart of sustainable development.

The government has failed to set a long-term goal to guide energy policy in the UK and this represents a fundamental barrier to the development of sustainable energy. Achieving sustainable energy will require consideration of every aspect of our energy systems from the production of energy to the energy delivery infrastructure to the services for which we require energy. There is no government department or body with the remit, or width of expertise, to take a balanced approach to energy, and this presents a case for the Agency adopting the role of advocate for sustainable energy.

The Environment Agency should do all it can to promote sustainability thinking and practices in the energy sector and contribute to the societal decision-making process about sustainable energy. However, until the Agency develops an energy policy position it will not know which energy practices it wishes to promote, and this will severely handicap the Agency's ability to take a lead role in encouraging the UK along a more sustainable energy pathway. In their recent review the Environment, Transport and Regional Affairs Committee criticised the Agency for not providing leadership in sustainable development. In their report they gave a vision of the

Agency taking a more active and bold position in setting the sustainable development agenda in the UK.

CONTENTS

1 INTRODUCTION

This is a discussion paper that explores the potential role of the Environment Agency in contributing to the development of sustainable energy in the UK. It is Paper 3 in a series of papers considering the issue of sustainable energy and the role of the Environment Agency. The increasing evidence that world climate is changing, and the Kyoto emission reduction targets, have brought somewhat of an urgency to the sustainable energy debate. It is now recognised that profound changes are required in our energy systems if we are to adequately reduce greenhouse gas emissions. However, substantial debate remains over exactly what a sustainable energy system will look like and how it will be realised. Therefore, determining the role of the Environment Agency in contributing to the development of sustainable energy is not easy. Nevertheless, there are three potential ways in which the Agency could contribute to the development of sustainable energy, which are outlined below and subsequently explored in more detail:

- **Through advocacy** - by actively contributing to the energy debate and participating in the energy policy development process;

- **By seeking to encourage the development of sustainable energy technologies and practices wherever it can** - such as through the delivery of its functional duties and through its relationships with all stakeholders; and,

- **By contributing to energy R&D** – to assess the sustainability impacts of different energy technologies, and advance the technological development and dissemination of "green" energy.

2 THE AGENCY AS AN ADVOCATE FOR SUSTAINABLE ENERGY

2.1 THE NEED FOR AN ENERGY TRANSITION

The production of energy is a primary cause of many environmental problems facing the UK and the rest of the world. The combustion of fossil fuels is both the primary source of local air pollutants such as NO_x, SO_X and particulates, and also of the global atmosphere pollutant, CO_2. In addition, fossil fuels are a finite resource whose availability will decline sometime in the future. Approximately three-quarters of the

UK's greenhouse gas emissions result from the combustion of fossil fuels for energy[101]. For the UK to reduce its greenhouse gas emissions to the levels recommended by the IPCC[102] will require a transition to a carbon-limited energy system during this century which will in turn require profound changes in the way we produce and consume energy. We should not underestimate the importance of undertaking this energy transition, nor the scale and profundity of the changes that will be needed. For these reasons achieving sustainable energy will be one of the key challenges in the pursuit of a sustainable way of life.

2.2 GOVERNMENT ENERGY POLICY

The UK does not have a clear long-term direction for its energy policy. Although it has a number of stated policy objectives, such as energy security and a reduction in carbon dioxide emissions, it does not translate these objectives into coherent policy measures. The UK government is unlikely to succeed in doing so until it has a clear vision of how it intends to achieve these objectives – it needs a vision of sustainable energy. Until, a clear long-term goal for energy policy is developed, UK energy policy will continue to lack direction.

Although the UK government is committed to greenhouse gas emission reductions and has set itself very challenging targets[103], its specific energy policy measures fail to match its commitments. A number of commentators believe that it will be extremely difficult to meet the government's renewable energy target with the current and proposed government policy, even though this represents just the first step along the road towards sustainable energy.[104] The UK starts from a much lower level of renewables penetration than do most EU countries. As is outlined above, addressing climate change in the long-term will require nothing less than an energy transition over the next half century or so. This will require substantial changes in the way we produce, transport and consume energy, but so far government policy

[101] (DoE, 1997) *Climate Change – The UK Programme*, HMSO, London

[102] The Intergovernmental Panel on Climate Change (IPCC) recommends a 60 – 80% reduction on 1990's level for greenhouse gas emissions from industrialised countries over the course of this century in order to ensure avoidance of potentially dangerous perturbation of the global atmosphere, (IPCC 1995) *The Science of Climate Change – Summary for Policy Makers*

[103] The Government aims for a 20% reduction on 1990s carbon dioxide emissions by 2010, and has a target for 10% of electricity to be provided by renewables by 2010 and 10 gigawatts of electricity to be produced by combined heat and power by 2010

[104] See "*Renewables Industry Braces Itself for Lean and Mean Future*", ENDS Report 301, February 2000

has failed to grasp the scale and fundamental nature of these changes. As a body committed to the promotion of sustainable development, the Agency should do all it can to communicate the magnitude of the changes that are necessary.

2.3 THE POWERS OF THE AGENCY – ITS ABILITY TO INFLUENCE THE ENERGY SECTOR

The regulatory work of the Environment Agency touches upon various aspects of energy production and use in England and Wales. The Agency regulates the electricity supply industry, nuclear waste disposal and oil refineries. It also recently acquired the duty to consider the efficiency of energy use by all industries it regulates. However, these regulatory duties cover only a few parts of our energy systems, and in delivering these duties the Agency hasn't the ability to strongly influence the main direction of energy practices in the UK. In order for the Agency to more fully influence the UK's energy systems, and the transition to sustainable energy, it will need to adopt more of an influencing and advocacy role. Nevertheless, having said that, it is clear that if the Agency does want to try and influence changes in energy practice through its functional duties it still needs to develop its own position on sustainable energy so that it knows what energy practices it wishes to promote.

Addressing the "energy sector" is so difficult because of the complexity of our energy systems, and the fact that they pervade every aspect of our economy and society. In order to influence energy practices we need to effect policy change in a huge number of sectors, such as industry, agriculture, housing and transport. There is no government department or body that deals with all these different aspects of energy, or that approaches energy at the overall system level, and this makes it difficult for the UK to move along a coherent pathway towards sustainable energy. This failure to take an holistic approach to energy has been identified by Green Alliance in their report, "The Case for a Sustainable Energy Agency"[105]. If there is no single government department with the remit, or width of expertise necessary, to take a balanced approach (as argued by Green Alliance and others), then there is a case for the Environment Agency adopting the role of advocate for sustainable energy. The Agency has already made a public comment on the need for the

[105] Green Alliance, 1999, *The Case for a Sustainable Energy Agency*

government to develop a long-term UK energy policy in order to ensure continuing carbon dioxide emission reductions in the longer-term.[106]

2.4 OPINION FORMING – A KEY PART OF SUSTAINABLE DEVELOPMENT

2.4.1 SUSTAINABLE DEVELOPMENT – A LEARNING PROCESS

The Agency should also adopt more of an advocacy role so as to more fully participate in the decision-making processes inherent within sustainable development. Government guidance states that the primary duty of the Environment Agency is to contribute to sustainable development through the delivery of its statutory duties and functions. (In seeking to contribute to sustainable development the Environment Agency is simply supporting the UK Government's overall aim of achieving sustainable development. In fact, as it is an overall policy aim of central government, the duty to contribute to sustainable development should be explicitly state for every arm of government. Indeed it is likely that other arms of government are better equipped in a number of ways to contribute to sustainable development than the Environment Agency.)

Environmental problems continue to increase because our economic system is undermining the environment and the resources upon which it depends[107]. It is clear that the regulatory duties that the Agency has inherited from its predecessor bodies cannot by themselves solve the environmental problems that the UK faces (the Agency has no powers to address a number of key economic sectors, it has only limited powers to influence those sectors that it does actually regulate and it has very limited influence over the UK's environmental footprint abroad). The roots of these problems lie deep within the workings of our current economic and societal systems, and the concept of sustainable development has arisen as a response to this situation.

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[106] (Environment Agency, May 2000), *The Environment Agency's Response to the Government's Draft Climate Change Programme*

[107] The term economic system is used here in its widest possible sense to refer to all the economic activities of society. The term resource is also meant in the widest sense to include all the environmental functions provided by the local, regional and global environment in addition to the physical resources that feed the economy.

Brundtland's is the mostly widely used definition of sustainable development; "development which meets the needs of the present without compromising the needs of the future" (WCED, 1987). However, this is a very unspecific and broad definition that leaves the main issues unresolved; namely, what are people's needs and how do we satisfy these without undermining our environment. These are issues that need to be resolved as the sustainable development process takes place. Nevertheless, it is clear that sustainable development is about change – it is about changing our model of development – and it will be a learning process because we have yet to decide exactly what our needs are, and how we can meet them sustainably.

Sustainable development is therefore a process and not a state. It is the process of changing our economic and social system to one that is environmentally sustainable. In additional to this sustainable development is also about achieving a society that is economically and socially sustainable – in that we need a healthy and vibrant economy which can satisfy our material needs and a fulfilling cohesive society that does not decline into crime or other forms of disorder. However, at this stage we do not yet know all the details about how to improve the sustainability of all the activities in our economy and society. The answers are not all laid out in front of us, but will require trial and error and an evolving process over time incorporating technological, institutional and cultural change. As Burgess et al (1999)[108] puts it, *"..sustainable development will remain a contested question that will continue to engage firmly with cultural and political issues in reaching judgements about the environment*". For this reason sustainable development is (and will continue to be) an inherently political process. Sustainability issues go to the heart of all decision-making in central and local government and in business. It is a learning process that will require debate and argument as to the best solutions, and it will not happen over night.

And above all the sustainable development process will require commitment to the sustainability cause. This is recognised by Burgess et al (1999), "*Fundamentally, sustainable development is about a change in values, and in particular the*

promotion of a set of values that raises the status of the environment when seeking to balance social, economic and environmental aspects of decision making". This demonstrates the clear role of the Environment Agency in promoting sustainability thinking and the interests of the environment at all levels of decision making in the UK. It is particularly important because sustainable development will require changes (in industry and all other economic sectors) and any change needs to overcome inertia and vested interests.

2.4.2 THE INVOLVEMENT OF THE ENVIRONMENT AGENCY IN THIS LEARNING PROCESS

As sustainable development is an inherently political process that will require tough decision-making across all tiers of government and society then in order to contribute fully to the process will require involvement in this decision-making. It would appear therefore that the Environment Agency is substantially reducing its scope for involvement in sustainable development if it seeks to avoid involvement in unresolved "political" sustainability issues that require opinion or positioning. If the Agency wishes to have a large impact upon sustainable development in the UK then it needs to be active in the sustainable development debate.

It is undeniable that the environmental campaigning groups, such as Greenpeace and Friends of the Earth, were those most responsible for bringing the concept of sustainable development to the fore by forcing society to recognise the unsustainability of its economic activities. The very fact that many of the "sustainability solutions" they promote are contentious only goes to show that sustainable development is a political process that requires debate and deliberation. Nevertheless, the fact that these groups so visibly force industry, government and the public to consider environmental issues means that they remain a key force for change, and therefore for sustainable development.

The Environment Agency could become a more powerful force for sustainable development by becoming a more outspoken advocate for sustainability solutions. Of course, the Agency will need to develop the messages, opinions and priorities

[108] *An Analytical and Descriptive Model of Sustainable Development for the Environment Agency*,

that it wishes to convey – but in this way it can contribute to the development of sustainability solutions and continue to encourage change.

Most people working to advance sustainable development still consider environmental understanding and awareness of sustainability issues to be the main barriers to progress. The Environment Agency also recognises that education is a vitally important part of the sustainable development process and it wishes to focus more on using education as a tool for obtaining environmental results[109]. The Environment Agency could become a more effective educator for sustainable development if it took more of an advocacy role and involved itself in the debate and policy process for vital sustainability issues. However, in order to do this it needs to develop its own opinion on key sustainability issues so that it can communicate a clear message.

2.4.3 THE SUSTAINABLE ENERGY DEBATE

The development of sustainable energy is a process because, in the same way as for sustainable development, we don't yet have all the answers. We have yet to decide exactly where we what to go, or how we'll get there. For this reason the development of sustainable energy is inherently a political process in the same way as improving sustainability in any sector. However, as I argued in section 2.2 the main barrier to the development of a sustainable energy system in the UK is the lack of a long-term goal for energy policy and a vision of what constitutes sustainable energy. If the Agency is to help remove this barrier then it needs to become more vocal in pointing out the need for a clearer direction for energy policy and it should seek to contribute to the development of a consensus over the future of our energy systems, and what a sustainable energy system might look like. When a consensus has been reached over the goal for energy, then the Agency can play its part in the process of developing consensus over how best to get there.

The potential energy sources that could figure in a sustainable energy scenario are renewable energy and nuclear power, although an equally important part of a

Environment and Society Research Unit, UCL, 1999

[109] See, for example, (Environment Agency 1997), *An Environmental Strategy for the Millennium and Beyond*

scenario will be the different types of infrastructure that can exploit and deliver the energy as this will help determine overall sustainability and the ability to meet society's needs. Technological developments could allow us to radically change the way we provide energy services, and, for example, in the future electricity needn't necessarily be generated at huge centralised power stations but at decentralised smaller local sites. The issues within the energy debate, and the ways in which the Agency might contribute, are considered in later sections of this paper. In addition, these issues are explored in far greater detail in Paper 2 of this series, "A Sustainable Energy Future – A Snapshot of the Issues".

3 ENCOURAGING SUSTAINABLE ENERGY PRACTICES AND TECHNOLOGIES THROUGH THE AGENCY'S WORK

3.1 THE POWERS OF THE AGENCY AND ITS CONTRIBUTION TO SUSTAINABLE ENERGY

Clearly, the Agency's regulation of power stations, nuclear waste disposal and oil refineries plays an extremely important role in lowering the environmental impact of energy production in England and Wales. However, up-to-now the Agency has played a very small role in helping to reduce the carbon dioxide emissions from energy production, and is unlikely to be able to do this to any degree in the near future by following the traditional pollution mitigation approach. This is for the obvious reason that the capture and disposal of carbon dioxide from waste stream gases is not currently a practical option as it is expensive and suffers from a number of technical challenges.

In order for the Agency to assess the contribution of its regulatory work to sustainable energy it needs to have a definition of what constitutes "sustainable energy". The general options for inclusion in a definition of sustainable energy are generally the same as those for addressing carbon dioxide emissions. These include:

- fuel switching to less carbon dioxide intensive fuel (e.g. coal to gas in electricity generation);
- the replacement of fossil fuels by non-carbon energy sources (i.e. renewables and nuclear); and,

- a reduction in energy demand through more efficient use of energy in all applications (including more efficient conversion technologies such as CHP and fuel cells).

In line with this, many people consider "sustainable energy" to equate with a transition away from fossil fuels to a more efficient energy system based on renewables. If the Agency were to adopt this definition then it would need to ensure that its work contributes to this transition in one way or another so as to contribute to "sustainable energy". The regulatory work of the Agency is concerned with improving the environmental performance of fossil fuel and nuclear generated energy – this could be perceived as simply managing the impacts of unsustainable energy as opposed to developing more sustainable practices. However, an energy transition will obviously involve a number of steps over many decades and we can be sure that fossil fuels will continue to play an important part in our energy systems for a long time to come, and so might nuclear. For this reason the current activities of the Agency are clearly an important contribution to sustainable energy and are likely to continue to be so for some time to come.

In managing this energy transition the Agency (and the UK) needs to identify the most "unsustainable" aspects of our current energy systems and work to replace or improve these, and identify those aspects that are more sustainable or could provide a useful stepping stone to sustainable practices. Technologies and practices that could contribute to the latter might include natural gas powered combined heat and power (with CCGT) and natural gas powered micro-CHP which can produce heat and electricity far more efficiently whilst also enabling a decentralisation of electricity generation which in turn is more favourable for renewables generated electricity. For the Agency to identify which technologies and practices it wishes to encourage in industry it needs to have an idea of where it wants to go (a vision of sustainable energy) and have a plan of how best to get there.

It is generally agreed that improvements in the energy efficiency of all processes and systems will improve the sustainability of energy use. Under the IPPC Directive the Agency will have responsibility for energy efficiency in all designated processes, and through this tool the Agency can influence carbon dioxide reductions. However,

the extent to which the Agency pursues efficiency improvements through IPPC will depend upon interactions with the Climate Change Levy (and associated Negotiated Agreements) and the voluntary Carbon Trading Scheme. Nevertheless it is clear that the Agency will have a role through IPPC, and contributions to the implementation/ management of the levy and trading scheme, in encouraging energy efficiency improvements in industry.

3.2 REGULATION OF THE ELECTRICITY SUPPLY INDUSTRY

Clearly, the Agency only has the power to regulate this sector in line with the pollution control legislation in EPA 1995 and earlier Acts. However, the Agency could develop its influencing and educational role in trying to influence the long-term direction of the electricity supply industry. If the Agency were to develop its own vision for the future direction of electricity generation and use in the UK it could work with the industry to move in this direction. The electricity industry has the potential to change significantly over the coming few decades, and the generation and use of electricity could become far more localised, whilst the number of large scale generating sites could decline. There could also be significant changes in the nature of large-scale generation - should the Agency begin encouraging generators to invest in offshore wind farms rather than conventional generation capacity? The Agency could organise seminars with the industry to discuss these issues, and the vision of a sustainable electricity industry.

If the electricity industry were to profoundly change in the way described over the coming decades this would also have substantial implications for the work of the Agency and the changing demands upon the environmental regulator. The environmental impact would change from consisting of a small number of large polluting sites to a large number of smaller more diffuse sites.

3.3 ENERGY USE AND BAT

Under IPPC the Agency has acquired the duty to have regard to the energy efficiency of the processes that it regulates. However, there is a much wider scope to sustainable energy management than simply applying a narrow focus on the energy efficiency of a very specific process. Should the Agency seek to compliment this tool with efforts to encourage industry to adopt other sustainable energy practices, such as CHP or the use of gas rather than coal as a primary fuel source? These would involve the Agency taking a wider, more general approach to energy practices, and it

could be done through a wider interpretation of the application of the BAT principle. It is clear that this wider interpretation of BAT would go beyond the present powers of the Agency because the Agency is only able to prescribe BAT for the specific processes which are outlined in the legislation. However, if the Agency felt that it would be better equipped to influence, or regulate for, sustainable energy if it acquired the ability to more widely interpret BAT in this way then the Agency could seek to acquire these powers. Nevertheless, if the Agency did not wish to formally seek powers for a wider interpretation of BAT at this stage, it could simply try to influence the energy practices of those it regulates through other, more informal, means. As briefly mentioned in section 3.1 above, the work of the Agency in this area would potentially have a dynamic interaction with the Climate Change Levy and the Carbon Trading Scheme.

3.4 WATER MANAGEMENT AND HYDROPOWER

The water management duties of the Agency have a substantial influence on the development of small scale hydropower in England and Wales and the actions of the Agency in this area will play a substantial role in the development of hydropower over the coming decades. Although small-scale hydropower is only one option of a number of renewable energy sources that may contribute to our energy needs the important role of the Agency in its deployment means that it deserves special attention. It is also a good test of the Agency's ability to approach its environmental protection work in a balanced way and to apply its functional duties so as to benefit the environment as a whole. In managing the development of small-scale hydropower schemes the Agency needs to consider the climate change benefit (and the lack of any other emissions) and potential local community benefits against the impacts upon the local water environment. However, the Agency has recently been accused of failing to take this balanced approach by being over precautionary with regard to the local impacts of small-scale hydropower schemes. In order for the Agency to resolve this issue and to undertake its duty to ensure that it takes a balanced view it needs to proactively contribute to the hydropower debate and to better inform developers, local councils and local communities as to the environmental requirements of small-scale hydropower schemes. The Agency should also develop its own opinion on hydropower in terms of its potential resource capacity in England and Wales and where the optimum sites are located.

The Agency should also consider the energy consumption, and energy efficiency, of water pumping schemes directly under its control, and the pumping undertaken by the water companies. Water pumping consumes a large amount of energy and the Agency could help to disseminate and encourage best practice (in terms of the energy source, the efficiency of the pump and the efficiency of the pumping system/design). The Agency should also have awareness of the energy consumption of water treatment works and the best practice in this area.

3.5 PARTNERSHIP WORK

The Agency could seek to improve its contribution to the development of renewable energy sources and energy efficiency schemes through participation at the local, regional and national level. The Agency's Area offices can work with local authorities through LEAPS and other routes to develop renewable energy and energy efficiency programmes within the local economy. The Regional offices can liase and work with the Regional Development Agencies to plan and develop sustainable energy initiatives at the regional level and the Agency's Head Office (the corporate Agency) can coordinate the consistency of the Agency's response on the ground. Decisions made at the local and regional level are likely to be of significant importance in the development of renewable energy over the coming decade. The Agency might also wish to become a partner in a national energy programme or campaign of some kind.

3.6 ENERGY USE BY THE AGENCY AND ITS ACTIVITIES

The Agency already has a programme to reduce its energy consumption as part of its overall environmental management programme, and eventually it will roll-out the environmental management system ISO14001 to all its buildings and activities. Nevertheless, the environmental management programme is still in its early days and the Agency has a long way to go before its own energy practices could be described as sustainable. Although the Agency is committed to improving the efficiency of energy use throughout its activities the priority afforded to its efforts could be greatly enhanced by the adoption of an energy position. This would also help the Agency to determine the sourcing of its energy and the importance it applies to obtaining energy from "alternative" sources. In particular the Agency should consider ways of reducing the amount of energy consumed in the construction, maintenance and operation of flood defence schemes. Not only does this energy use represent a very large demand, but it could also involve the Agency demonstrating

good practice and leading the way in showing how improvements can be made. The Agency could also insist that small generating turbines are placed on all new sluice gates and other structures with close proximity to running water.

4 HOW WOULD AN ENERGY POSITION BENEFIT THE AGENCY?

4.1 THE AGENCY'S ENVIRONMENTAL VISION

In 1997 the Environment Agency published "An Environmental Strategy for the Millennium and Beyond" which aimed to provide the Agency with an holistic approach to protecting and improving the environment. The Agency is currently in the process of reviewing this strategy so as to provide a more effective framework for developing the Agency's contribution to environmental protection and sustainable development. This new "Environmental Vision" concentrates on the wider sustainable development picture and the need for the Agency to "become a force for positive change". It states that the Agency needs to examine and question its role in setting the sustainable development agenda. The current draft of the Environmental Vision also states that, "...we will express opinions upon other areas that have a high environmental impact", and, "...we will spend more time on education and influencing than we have in the past". Addressing energy issues is of vital importance for a number of the Environmental Vision's Frameworks for Change, including "Ensuring that the Air is Clean", "Limiting and Adapting to Climate Change", "Greening Industry" and "Using Natural Resources Wisely". Each of these frameworks has an accompanying vision statement, and yet they do not have a vision of how our energy systems will need to change so as to enable these environmental visions to come about. But surely it is as important to have a vision of the character of our future energy systems, and other key sustainability issues such as our transport system, as it is to have a vision of the future condition of the environment. Otherwise, how will we achieve the vision of "clean air" or "a stabilised climate"?

Therefore, the Environmental Vision provides a strong argument for the Agency's involvement in setting the sustainable development agenda and it states the Agency's direct intention to be more opinionated and more widely active in sustainability issues. However, the document as it stands is inconsistent in that it

states that the Agency intends to become a force for change and to express its opinions, and yet within its thematic approach it still fails to confront the kind of bold decision-making and leadership that will be required to deliver the kind of environment we all want. Of course, the document itself is only the framework for the strategy and so perhaps the evolving implementation of the Vision over time will deal with this in the future.

Nevertheless, the argument for a sustainable energy advocacy role for the Environment Agency is consistent with the principles outlined in the Environmental Vision and the new direction that it wishes for the organisation. The comments provided by the Environment, Transport and Regional Affairs Committee in their Sixth Report on the Environment Agency suggest that they have a similar vision of the work of the Agency. They criticised the Agency for not providing leadership in sustainable development and they stated, "We look forward to seeing an Environment Agency which takes its place as the leading organisation in the process of attaining that goal (sustainable development)". Having received this criticism there is no reason for the Agency to be tentative in its approach to sustainable development, and it will be difficult for the Agency to show leadership if it does not develop its opinions on key sustainability issues – then it can seek to direct industry and energy onto more sustainable pathways.

4.2 HOW CAN THE AGENCY ENCOURAGE SUSTAINABLE ENERGY IF IT HAS NO OPINION ON WHAT IT IS?

As has been argued in the previous sections, the Agency needs at least some kind of an energy policy position if it is to try and influence the development of sustainable energy either through the encouragement of sustainable energy technologies and practices through its work on the ground, or through the adoption of an advocacy role. Unless the Agency has a position on sustainable energy it will not be consistent in its approach, and it may fail to provide support and direction when the opportunity exists.

4.3 AN ENERGY POSITION WOULD GIVE ENERGY THE PRIORITY IT DESERVES

Achieving sustainable energy will be a key component of sustainable development due to the key contribution of energy use to climate change and the dependence upon energy consumption in industrialised society. Our present energy systems are based

on fossil fuels and are designed around the characteristics of fossil fuels. The characteristics of alternative energy sources such as renewables are very different. The current energy market is also focused on the supply side, and is not well structured to deal with the vast opportunities for improvements and developments in the use of energy. The infrastructure, market structure, policy structure and the knowledge and skill-base of the majority of the workers and institutions in the energy industry are all designed around the old unsustainable workings of our current systems. These will all form obstacles to the transition to a different and more sustainable energy system.

However, at the moment in the delivery of its work the Agency may not be paying attention to the potential for, and the importance of, energy efficiency improvements or the switching to alternative energy sources and practices. These concerns are not represented in the guiding legislation and the primary duties of the Agency, and for this reason will not be at the forefront of the minds of Agency staff. If the Agency were to have a high profile energy position statement that outlined the Agency's definition of sustainable energy and those technologies and practices that the organisation wishes to promote and support then this would raise the priority of energy in the Agency's work. This may also help Agency staff to identify more opportunities for promoting better energy practices.

4.4 WHAT FORM MIGHT AN AGENCY ENERGY POSITION TAKE?

4.4.1 AN AGENCY ENERGY POSITION - THE ISSUES TO BE RESOLVED

The central line of argument of this paper has been that the Agency needs some kind of energy position in order to inform its actions. But what shape should this position take? Would it need to be highly detailed to be of any benefit, or could it simply be one of following Government policy intentions for the environment and energy? Section 2.2 outlined the main failings in current Government policy. Firstly, that there needs to be a long-term view of sustainable energy to inform present day policy making (and a long-term signal for business) and secondly that the government's energy policy measures for addressing climate change are not anything like as significant as they need to be. The Agency would need an energy position that enables it to comment on these weaknesses and to support those energy

technologies and practices that it considers sustainable. As outlined in section 3.1 the main candidates for the title of "sustainable energy" (in the face of climate change) include renewable energy, more efficient use of energy and nuclear power.

The Agency might want to undertake its own analysis and consensus building process to develop its own vision of sustainable energy that satisfies environmental, economic and social criteria such as climate change, visual impact, energy security, adequate supply and economic competitiveness. The energy debate is a very complex one because of the huge number of variables that need to be taken into account, and the need to consider how these variables might change in the future. I believe that the best way for the Agency to manage some of these complexities, and also avoid being dragged into the quagmire of day-to-day energy policy, would be through the adoption of a realisable but visionary long-term goal as its energy position. Whilst avoiding the complex details of everyday policymaking, a long-term vision of sustainable energy would nevertheless guide the Environment Agency in determining its own priorities for energy and energy technologies. And, as the UK does not have a long-term goal for energy, the development of a vision of sustainable energy could potentially play an extremely useful wider role.

4.4.2 AN AGENCY ENERGY POSITION AND GOVERNMENT ENERGY POLICY

Of course, the Agency might need to be careful in the way it expresses its energy position if it wants to avoid upsetting the government departments.The Agency could quite easily ensure that it keeps all its comments and actions within government's broad policy aims. For example, the Agency could have as its policy the following statement:

"The Environment Agency supports renewables and energy efficiency, and would like to see them replace fossil fuels in a long-term transition away from a carbon intensive economy. The Agency will do all it can in the delivery of its work to promote and encourage their development where it is possible and with due regard to the environmental, economic and social implications".

This is within the bounds of present government policy because it promotes renewables and energy efficiency, and like government policy it has nothing to say on the future of nuclear power. Only if the Agency were to begin promoting nuclear power would there necessarily be conflict with Government (and many others besides). The commitment of the government to sustainable development and to addressing climate change provides the Agency with the ability to comment quite extensively whilst still keeping in line with government policy because of the width of interpretation that is possible under these broad policy aims. For example, it is quite within the Agency's rights to point out to government that it's commitment to reducing greenhouse gas emissions in the longer-term could be jeopardised by its failure to ensure that lost nuclear capacity over the coming decade is replaced by carbon-free energy sources or offset by efficiency gains.

However, it is undoubtedly true that if the Agency decided that it wanted to make an important comment on the future of nuclear power - such as prescribing high-level policy measures - it would need to carefully consider its way forward.

4.4.3 UNACCOUNTABLE DECISION-MAKING?

The Environment Agency is in a difficult position. On the one hand it is tasked with contributing to sustainable development (and variously encouraged to be a force for sustainable development), which, as is argued in section 2.4 above, is an inherently political process, and on the other hand it is a government body, whose powers and duties are prescribed by government and which has no mandate to engage in "political decision-making". In addition, the Agency has not been allocated the resources to invest in new research should this be needed to inform its opinions. However, there is a lot of scope for the Agency's involvement in key sustainability debates without it jeopardising its integrity through making "unaccountable" decisions. Firstly, the Agency has not got the power and influence to be a threat through its "unaccountable" decision-making (which was not true of the powerful decision-taking QUANGOs under the previous government who instead of contributing an argument to the debate were the sole decision-maker). Secondly, the Agency has the mandate to promote the interests of the environment and to encourage the wider (and balanced) environmental considerations associated with any development, activity or decision. But in doing this the Agency needs to outline

priorities for environmental protection in terms of the impact on, or contribution to, sustainable development. Sustainable development is about engineering societal and economic change and if the Agency is frightened of involvement in subjective decision-making (that are described as political in the rest of this paper) it will reduce its impact on the sustainable development agenda.

4.4.4 CAN THE AGENCY BE A FORCE FOR SUSTAINABLE DEVELOPMENT WITHOUT HAVING AN IDEOLOGY?

When it comes to forming an opinion it is clear that the Environment Agency has no ideology or vested interest in the same way as the environmental campaigning groups, and the various lobbying interest groups, who are the most vocal participants in the environmental and sustainability debate. On the one hand this may be perceived as a great advantage in that the Agency could enter the debate as a rare impartial and thereby contribute a well-respected and expert opinion on various aspects of sustainable development. On the other hand the lack of an ideology or specific vested interest could in fact be a great handicap, and that is because the Agency has no collective message that it may wish to contribute to the debate. Although the Agency has the duty to protect and enhance the environment, this does not mean that the organisation, or its staff, will automatically have a commonly agreed opinion on key sustainability issues such an energy or transport. This reflects the extreme complexity and political nature of environmental decision-making and sustainable development. Agency staff come from many different walks of life – in fact, the cross-section of different opinions and beliefs within the Agency may well reflect the cross-section of opinion within society as a whole – and therefore their opinions with regard to various sustainability issues will also be very diverse.

This is not to say that the Environment Agency, as a body tasked with contributing to sustainable development, should shy away from confronting its duty to stimulate and promote sustainable development. More than any other organisation it should seek to encourage change and communicate the scale of the changes that are necessary. In order to do this effectively may well require the Agency to seek to achieve a consensus on a number of the key sustainability issues such as energy and transport.

APPENDIX 4

DISCUSSION PAPER 1

A SUSTAINABLE ENERGY FUTURE:

A SNAPSHOT OF THE ISSUES

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FEBRUARY 2000

CONTENTS

A SUSTAINABLE ENERGY FUTURE – A SNAPSHOT OF THE ISSUES

1 INTRODUCTION

1.1 The Need for An Energy Transition

The production of energy is a primary cause of many environmental problems facing the UK and the rest of the world. The combustion of fossil fuels is both the primary source of local air pollutants such as NO_x, SO_X and particulates, and also of the global atmosphere pollutant, CO_2. In addition, fossil fuels are a finite resource whose availability will decline sometime in the future. Approximately three-quarters of the UK's greenhouse gas emissions result from the combustion of fossil fuels for energy[110]. For the UK to reduce its greenhouse gas emissions to the levels recommended by the IPCC[111] will require a transition to a carbon-limited energy system during this century which will in turn require profound changes in the way we produce and consume energy. We should not underestimate the importance of undertaking this energy transition, nor the scale and profundity of the changes that will be needed. For these reasons achieving sustainable energy will be one of the key challenges in the pursuit of a sustainable way of life.

1.2 The Development of a Vision

This is paper two in a series of papers considering the issue of sustainable energy (see Appendix 1 for a list of these papers). This paper aims to provide an overview of the key issues involved in the debate over future energy systems, and those issues that will need to be considered in the development of a vision of a sustainable energy system. It is not possible to give a thorough analysis of all the issues involved and so this paper will not seek to outline all the technical details surrounding the various renewable energy technologies or the potential of energy efficiency technologies. Instead it will attempt to set the context of the debate and to explore the various ways of approaching the analysis of sustainable energy. Paper 1 in the series gives an

[110] (DoE, 1997) *Climate Change – The UK Programme*, HMSO, London

[111] The Intergovernmental Panel on Climate Change (IPCC) recommends a 60 – 80% reduction on 1990's level for greenhouse gas emissions from industrialised countries over the course of this

introduction to this visioning work and the potential role of the Agency in contributing to the realisation of sustainable energy and Paper 2 outlines the current understanding of climate change and the imperative for change in our energy systems.

1.3 The Need for a Vision

This paper takes as its starting point the observation that the UK does not have a clear long-term direction to its energy policy. No government department deals with every different aspect of energy or approaches energy at the overall system level which makes it difficult for the UK to move along a coherent pathway towards sustainable energy. This failure of the UK Government to take an holistic and balanced approach to energy has been identified by Green Alliance in their report, "The Case for a Sustainable Energy Agency"[112]. However, it is not the intention of this paper to undertake a large-scale review of the environmental implications of energy policies currently in place or under discussion. One of the most obvious examples of two policies in direct conflict with each other is that of the Government's moratorium on new build of natural gas powered CCGT (which have been responsible for the majority of UK carbon dioxide reductions over the course of the last decade) alongside the UK's commitment to carbon dioxide emissions reductions. The Government could improve the coherence and direction of its energy policy if it were to develop a vision of where it wants to go. The lack of a long-term goal for our energy systems is delaying progress towards reducing the environmental impacts of energy production, and in particular the release of greenhouse gases. A long-term goal for energy policy would guide policy development and day-to-day decision-making, and provide a framework against which to evaluate the sustainability of energy policies as they develop. It would also improve the confidence in the market place for long term investment in sustainable energy technologies and infrastructure. However, this paper does not concern itself with the

century in order to ensure avoidance of potentially dangerous perturbation of the global atmosphere, (IPCC 1995) *The Science of Climate Change – Summary for Policy Makers*

[112] Green Alliance, 1999, *The Case for a Sustainable Energy Agency*

policy instruments and the steps that will be required to direct our present-day energy system to one that is more sustainable. It only concerns itself with the development of the long-term vision itself.

1.4 A Vision to Guide Climate Change Policy

It is only natural for the UK Government to take advantage of the more easily attainable emission reductions for the 12.5% Kyoto target.[113] Government will first access those reductions that can be most easily targeted by policy instruments and those that will bear fruit in a short time period. For future emissions targets, beyond Kyoto, this leaves those emissions that are more difficult to control (in terms of designing effective policy measures), and those emissions for which policy instruments will take a longer time to take effect. Beyond 2012 the UK will face stricter greenhouse gas emissions targets under the UN Framework Convention on Climate Change. In order to meet these stricter future targets the UK will have to begin to undertake reductions in its consumption of fossil fuels because fossil fuel combustion contributes three quarters of UK greenhouse gas emissions (in terms of global warming potential). However, it is likely to be extremely difficult to do this unless steps are taken today to influence the long-term difficult-to-access emission reductions. For example, in the electricity sector after 2012 it is likely that the nuclear power contribution will begin to decline as stations become obsolete. In the liberalised electricity market the costs of nuclear power are too large to interest private investment in new reactors and the government currently has no interest in heavily subsidising the construction of new nuclear capacity (in addition the process of authorising and building new power stations is a very long one). If this reduction in capacity from both nuclear and fossil fuels is to be replaced by renewables capacity, whilst also taking account of possible increases in energy demand (which could be likely unless there are more effective policy measures for improving efficiency of energy use), then the growth in renewables will need to be substantial indeed. The necessary renewables capacity will not be available at this time unless bold measures are put in place today to substantially boost the development and

[113] The UK's Kyoto target is a 12.5% reduction on the 1990 levels of the basket of six greenhouse gases by the budget period of 2008 to 2010 (this includes carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexaflouride).

uptake of new and renewable energy technologies. The government should also set further, more substantial targets beyond the challenging 10% carbon dioxide reduction target for 2010 so as to encourage long-term investment in renewable energy technologies and provide direction for the market place.

The evolving UK climate change programme, aimed at achieving the Kyoto target, currently has very few policies to tease out emission reductions in the domestic sector precisely because these emissions are difficult to get at. However, large-scale improvements in the energy performance of buildings will take decades to engineer and yet this will need to play an important role in meeting future reduction targets. In addition it could be very difficult to achieve emission reductions in the transport sector as individual travel continues to grow – although developments in telecommunications could enable substantial changes in working and cultural practices. Therefore, the UK will only be able to achieve future emission targets by considering today the many different ways in which it could meet its energy needs in 2020, and in 2050 and beyond, and outlining a vision of a sustainable energy future. The technological and institutional opportunities for changing our energy systems are vast and the UK needs to determine a pathway by which it can utilise new technologies to achieve a sustainable energy system later this century. This requires a vision which identifies and prioritises the opportunities available for changing the way we use energy and deliver our energy services, and the opportunities for more effectively exploiting available energy sources. In so doing the vision would prioritise those energy sources on which the UK should concentrate over the coming century. This vision would therefore outline the general pathway that the UK seeks to follow and highlight where new investment needs to be focused.

In this analysis I will also take as a given the compliance of other countries with their own greenhouse gas reduction targets, and the general drive by all countries for more sustainable practices. This removes from the analysis sticking points such as, "what if other countries don't similarly reduce their emissions, then what's the point of the UK doing so?" (although, in fact, there are a number of economic arguments suggesting benefits for the UK in taking a lead in emissions reductions), and the economic competitive issues that could arise from the UK acting in isolation. However, it is clear that without a successful Kyoto Protocol it will be difficult for

the world to move forward on the climate change issue. Nevertheless an analysis of the integrity and likely success of the Kyoto protocol would require a whole paper (or book) to itself.

2 A BREAKDOWN OF UK ENERGY USE AND ENERGY-RELATED CARBON DIOXIDE EMISSIONS

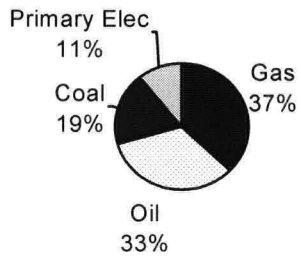
2.1 The Different Ways of Approaching an Analysis of Energy

If we are to consider how to reduce the carbon dioxide emissions arising from energy use, then it is important to have an idea of how and for what reasons energy is being used, and hence what activities are associated with the highest carbon dioxide emissions. We also need to have a good understanding of how our current energy systems operate if we are to think about alternative systems for meeting our energy needs.

The term *energy system* refers to everything that is involved in getting a particular energy service to a particular customer. As with any statistical breakdown there are a variety of ways available of presenting the energy flows in society. For example, UK energy use can be assessed either through a break-down of the energy used by different economic sectors or through a breakdown of the quantities consumed of the different fuels. In turn this energy use can be measured upstream or downstream in the economy, such as the primary energy that is fed into the economy or the energy that is used by the end users. The ability to present energy statistics in different ways can lead to confusion. For example, if the energy use of an electricity user is represented in terms of the energy content of the electricity used then this hides the overall energy footprint because of the large energy wastage in the generation and transmission of the electricity. The carbon dioxide intensity of energy use is also complicated by the fact that the different fuels (coal, oil & gas) emit differing amounts of carbon dioxide, and that more efficient combustion hardware will use less fuel and therefore produce less carbon dioxide. One of the reasons why electricity generation is such an important source of carbon dioxide emissions is because it is the largest user of coal, and the old coal power stations are very inefficient compared to the modern gas stations.

Energy is required in order to provide a service of some kind, such as keeping us warm in winter, powering our television sets or powering an industrial process. As we are interested in reducing the environmental impact of our energy systems, the

best approach is to focus on the services that energy is used to supply and then evaluating the overall energy efficiency involved in providing these services. This may lead to a radical re-appraisal of our energy systems in terms of how we satisfy our energy needs. Many aspects of our current energy systems are rather inefficient in providing these services, and where this is the case it would be better to change the way in which we provide the energy service rather than simply concentrate on the primary fuel inputs to the economy. For example, domestic electric heating is a very inefficient way of warming a home compared to a gas heating system. Electricity generation has a conversion efficiency of 25 –50% (in terms of the energy content in the fuel that is converted into electricity) and there are further losses in transmission, and in the conversion of the electricity back to heat energy in the home. A thorough analysis of our energy systems may reveal a large number of ways to improve the resource efficiency of our exploitation of energy resources – i.e. the ratio of the energy input to the service output.



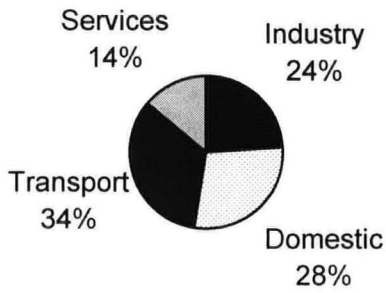
2.2 The UK Fuel Mix for Primary Energy Consumption (Digest of UK Energy Statistics 1998)

The primary electricity is mainly nuclear with a small hydropower component, and a very small contribution from of other renewables such as biomass and wind.

2.3 A Sectoral Breakdown of Energy Consumption

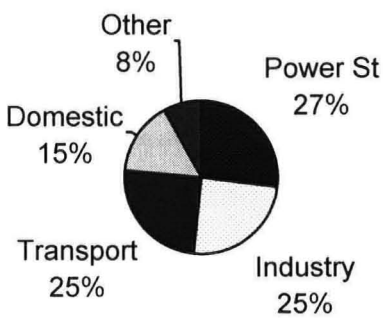
The single largest use of energy is for space and water heating which constitutes the bulk of the domestic usage, but also a substantial proportion of the commercial, public and even industrial sectors. Industrial energy demand has been falling with a 5% decline in the period 1990 to 1995. Energy use by households and transport has increased.

UK Final Energy Consumption (Digest of UK Energy Statistics 1998).



Although only 20% of the energy consumed by final users in the UK is provided in the form of electricity, the generation of electricity uses nearer 30% of the primary energy input. It is this reason, coupled with the fact that electricity generation is still the biggest user of coal (even though the trend is one of a substitution by gas), that results in electricity generation being the single biggest source of carbon dioxide emissions in the UK - contributing over a quarter of all emissions. Electricity consumption continues to grow in all sectors.

UK Carbon Dioxide Emissions by Sector (Digest of UK Energy Statistics 1998)



The emissions associated with the electricity used by the domestic sector are not covered by the domestic slice in the chart but are subsumed within the overall power generation sector. The same is true of the industry segment although industry also generates some of its own electricity. It is interesting to note that although the transport sector uses the most energy its carbon dioxide emissions are less than those

of industry. This is probably because industry still burns fairly substantial quantities of coal and is a large electricity user.

2.5 Energy Intensity of the UK Economy

The energy intensity of the economy has decreased by over fifty per cent since 1950 – GDP is fifty per cent bigger but primary energy use has remained the same. However, this is not only due to energy efficiency improvements but also because of fuel switching in electricity generation, a decline in the relative importance of energy intensive industries and the fact that some energy inputs, such as space heating, don't necessarily increase at the same rate as economic output. The substantial opportunities for improvements in energy efficiencies throughout the economy should mean that this trend continues so that the energy intensity of the economy continues to decrease.

2.6 Heat and Transport: The Main Users of Energy

Even though electricity generation (and therefore electricity use) is responsible for a quarter of energy-related carbon dioxide emissions, it is still important to consider the other main energy demands in the UK. As stated above transport and space heating represent the two biggest energy demands, and at present these are mainly satisfied through the combustion of oil and gas respectively. Coal, oil and gas are also used in the production of high-temperature heat for industrial uses. Therefore, in considering a transition away from fossil fuels (so as to substantially reduce carbon dioxide emissions in the long-term) it is important to determine how the various alternatives (i.e. nuclear and the renewables) can substitute for fossil fuels in supplying heat and motive power.

3 AN ALTERNATIVE ENERGY SYSTEM – THE OPTIONS AVAILABLE

3.1 Carbon Abatement – A Direct Technological Solution?

This paper has argued that in order to significantly reduce carbon dioxide emissions arising from energy production then the only long-term option is to reduce the contribution of fossil fuels to the fuel mix. But what about carbon dioxide abatement? Why can't we simply collect carbon dioxide at source, and then inject it into the ocean or into empty natural gas fields?

At present there is no viable technology for undertaking this emissions capture at an acceptable cost, and the technique would also require a reliable long-term storage site for the carbon. Technological and scientific development may, in the longer-term, enable a complimentary relationship between carbon dioxide capture and carbon dioxide storage methods, such as the storage of carbon dioxide in the oceans or even the injection of carbon dioxide into exploited oil and gas fields. However, because all these methods are presently in the theoretical or very early R&D stage, it is not sensible to pin a great deal of hope on them, and it is certainly unwise to believe them to be the complete answer to the carbon dioxide problem.

Nevertheless, we can't completely rule out the possibility of carbon dioxide mitigation techniques enabling fossil fuels to retain a small role in our energy mix for many centuries, without compromising climate change treaties. Carbon dioxide capture technology along with the development of other technologies such as coal gasification could in the longer term enable practical and economic clean fossil fuel energy production.

3.2 The Significance of Natural Gas

Natural gas is the cleanest of the fossil fuels in all respects. It burns cleanly and also produces the least carbon dioxide of the fossil fuels. On top of this, natural gas is an extremely flexible and useful fuel and can be easily transported anywhere and burnt efficiently in very large or very small quantities. It is also equally efficient generating electricity in small or large units. The 1990s saw a huge growth in the number of combined cycle gas turbines in electricity generation where the benefits

of the clean burning properties of natural gas allow it to undergo a combined cycle of electricity generation which enables highly efficient energy conversion and results in far less carbon intense electricity. For these reasons natural gas is very important environmentally and its substitution for the other fossil fuels should be welcomed. Natural gas could also provide a fuel source for fuel cells through conversion to hydrogen (the efficiency of fuel cells is outlined below). However, concerns about the over-reliance on one type of fuel and the fact that increased consumption of natural gas will increase the speed of its depletion in the North Sea is a long-term problem for the UK. Nevertheless, the useful flexible properties of natural gas along with its comparatively low carbon dioxide emissions means that it is likely to be an important fuel in the 21st Century and in the transition to a more sustainable energy system.

3.3 The Practicable Options for a Sustainable Energy Future

3.3.1 Energy Efficiency, Renewables and Nuclear

However, a consideration of the practicable options available today, and for the foreseeable future, for reducing carbon dioxide from our energy systems leaves the following options:

- Reducing energy demand

- improvements in end-use energy efficiency;
- improvements in the energy efficiency of the energy infrastructure (more efficient technologies and the development of new delivery systems;
- introduction of more efficiency conversion technologies such as fuel cells;
- cultural/ behavioural changes brought about by technological changes e.g. telecoms, or value changes, and

- Changing the energy source

- an increased contribution from nuclear power;
- the bringing on-stream of renewables.

From a climate change perspective, a long-term vision for sustainable energy could consist of quite a variety of different combinations of these energy technologies, and fossil fuels may play some role well into the 22nd Century and beyond – either because practical considerations means that they will be difficult to replace for some applications or because we develop the capability for using them cleanly.

3.3.2 Contentious Issues

It is generally agreed that energy efficiency improvements and renewables will need to play an increasing role in our energy systems. However, there are many disputes concerning the precise magnitude of their future roles, and in particular the upper limit to renewables resource capacity and energy efficiency improvements. The issues over which there is argument include the technical capabilities, the economic cost, the barriers to market penetration and the environmental impacts. However, for many years, the biggest disagreements in the energy debate have been over the future role of nuclear power. Nuclear power is generally unpopular with the public and for many years the green lobby has been calling on government to formally discontinue the nuclear programme. However, this nuclear debate is now becoming subsumed within the energy and climate change debate. Nuclear power represents the only alternative (technically-available) *concentrated* energy source to fossil fuels and a nuclear powered electricity system represents the only *direct* alternative to our current system – i.e. the centralised large station powered electricity system. However, the centralised electricity system is not the only model of electricity generation and supply, and neither is it necessarily the best model. The flexibility of natural gas and the high efficiency and economic benefits of micro CCGT CHP plants is already beginning a process of decentralisation of the electricity system. Many people within the nuclear fraternity are pointing out that it may be unwise to phase-out nuclear power if we are unsure of the capability of renewables in satisfying our energy needs. Clearly, there are many complex issues that need to be considered when determining the best alternative, and it is the purpose of this paper to briefly introduce the full width of issues that need to be covered.

3.3.3 Nuclear Versus Renewables?

Section 5 looks at the main sustainability criteria against which the main energy options must be evaluated. The approach that I have taken in carrying out this general sustainability assessment is to consider two alternative energy systems that represent the main two positions in the sustainable energy debate. These are a renewables intensive and a nuclear intensive system. Of course, a third system could consist of a mix of nuclear and renewables, and there are a number of people who have their minds open to this mix. However, I am only considering the two extremes of a renewables intensive system and a nuclear intensive system because this will be sufficient in illustrating the arguments and the issues that surround the debate. It is also the case that a large proportion of those people who are supporters of a renewables based energy future would not tolerate the suggestion of a renewables-nuclear mix, because they are staunchly anti-nuclear. They believe that the climate change risk and the nuclear risk represent two of the greatest environmental threats posed by modern society.

3.4 The Main Characteristics Of A Nuclear Future

We already have an energy system with a large input from nuclear power and so we are fairly familiar with what a nuclear-based energy system would look like. Nuclear power is perfectly suited for our centralised electricity system based on large isolated generating stations. However, nuclear engineers will no doubt have a vision of how they could make things better. There are several issues that need to be resolved if there is to be a continuing and growing nuclear programme as a substitution for fossil fuels:

- The on-going debate about the disposal of high level **radioactive waste.** Of course, the quantities of waste would increase under an increased deployment of nuclear waste and so this issue would grow in importance;

- The **decommissioning** process has only just begun for the earliest Magnox reactors. This will be such a long process that only time can tell as to the problems it may encounter and the overall financial costs;

- The substitution of nuclear power for **non-electricity energy applications** - at present, nuclear power only contributes to electricity production, but only about a fifth of the UK's energy consumption is supplied in the form of electricity. Therefore, in a nuclear intensive scenario we would need to find ways of introducing nuclear generated energy to important non-electrical uses such as transport or space heating. This could be done by converting to electric cars and by converting all heating systems to electrical ones. A further option may be one of establishing small-scale nuclear combined heat and power plants throughout our communities and in industry. However, it seems unlikely that the public would allow large numbers of nuclear facilities throughout the urban area and increasing the number of facilities in this way would increase the safety risk and in parallel the cost of nuclear derived energy;

- **Uranium**, the fuel of existing power stations, is a **non-renewable resource** that at current mining rates probably has a life-span of less than one hundred years. For this reason unless commercial fast breeder reactors which can use plutonium as a fuel can be safely developed then nuclear power itself will not be a long-term energy option;

- Operating practice has shown nuclear energy to be **very expensive**, and it has needed to be heavily subsidised by government. It is certainly more expensive than fossil fuel derived power, and more expensive than most wind generated electricity. Therefore, high energy costs might well be a feature of a nuclear intensive scenario;

- If the UK were to choose nuclear power as its main energy source for the future it would send out to the rest of the world the message that nuclear power is the answer to climate change and all the other environmental and economic challenges involved in achieving sustainable energy. This may send the signals for a more nuclear intensive world, and all the dangers this raises of **nuclear proliferation**, increased nuclear shipment and weaker safety standards in poorer countries.

3.5 The Main Characteristics Of A Renewables Future

3.5.1 A Definition Of Renewable Energy

Renewables currently supply approximately three percent of the UK's electricity with three-quarters of this coming from large-scale hydropower mainly based in Scotland. All the acceptable sites for large-scale hydropower were taken advantage of long ago. Therefore, the technologies that would play the main role in a renewables intensive scenario have yet to make any significant contribution to our modern energy systems.

It is very important to clarify what we mean by the term renewable energy, and in fact there are disagreements over what can count as a renewable energy source. The Government has a very wide definition and their renewables classification includes landfill gas, energy from waste (incineration) and agricultural wastes. Indeed, these are officially described as "green" energy sources under the Energy Saving Trust "Future Energy" accreditation scheme for green electricity. However, the environmental groups do not agree with this definition and argue that energy from waste cannot be described as a renewable energy source. Indeed, it is clear that energy from waste is not strictly renewable because most of the components within the waste stream are not from renewable sources. Waste paper produced from sustainably managed forests could be described as a renewable energy source but very few other constituents of waste could qualify. Waste incineration is a waste management option, and if it produces energy at the same time then clearly it is sensible to take advantage of this. However, it is unlikely that in the long-term sustainable waste management practices will contain a large incineration component. Our excessive waste generation is a prime illustration of our current unsustainability, and will need to be tackled in our progress towards sustainable development. Therefore, it is incorrect to include energy from waste in a definition of renewables, and it is unlikely that energy from waste will play anything more than a very minor role in our energy systems in the long-term. Thus, when using the term "renewables" from this point onwards I will refer to onshore and offshore wind, energy crops, solar heating, photovoltaics, micro-hydropower, wave, tidal and geothermal energy sources.

3.5.2 Current Situation of the Renewable Technologies

- **Onshore wind power** is the most mature of the renewables technologies, and electricity from wind farms is currently near the general pool price. The development of wind power over the last fifteen years has been substantial. Offshore wind is now a real possibility for the UK, particularly with the arrival of very large turbines of 2 MW, and the Danes already have a few small offshore wind farms with plans for many more in the next thirty years. An assessment of the UK offshore wind resource by the European Commission estimates the potential to supply over three times the current UK electricity consumption.[114] Offshore wind has the two advantages of taking the turbines off the land (although the wind farm would still be visible from onshore) and of ensuring a more constant wind speed than is found onshore, but has the disadvantage of increasing the cost and the distance of transmission.

- **Biomass** - The present economic situation for UK agriculture could favour the production of energy crops and enable them to compete in the energy market place. Energy crops are considered to be the second best placed renewable at the present time in terms of their cost and readiness for the market place. Although the potential for energy crops is not as large as for wind energy due to agricultural land constraints, it nevertheless could play a substantial role.

- **Photovoltaic cells (PV cells)** have been a competitive technology for remote sunny locations for some time, and, at present, in the UK they are very expensive and uncompetitive except for highly specialised uses. However, there are arguments over the likelihood or otherwise of their price falling substantially over the next five years, and their suitability as a cladding for buildings increasing in parallel. Greenpeace and some other environmental groups believe PV is going to be one of the main UK energy technologies in the future, whereas others think it unsuitable for the British climate.

[114] H.G. Matthies (1995). *Study of Offshore Wind in the EC* JOUR 0072, Verlag Naturliche Energie. Referenced in Greenpeace report *Offshore Wind Energy – Building a New Industry for Britain*, 1998

- **Wave power** has received little investment over the last ten years and is considered by ETSU to be a long-term technology that requires more research investment and won't be mature for at least another ten years. However, wave power also has the potential to produce substantial amounts of electricity, and should not be disregarded in terms of its ability to supply power in the future.

- **Tidal energy** could also contribute sizeable quantities of electricity to an overall renewables mix thereby displacing the equivalent of a number of large fossil fuel power stations. Tidal energy can be harnessed in two ways. The first involves the construction of a large barrier which is able to intercept significant amounts of energy but leads to substantial ecological impacts which are considered unacceptable by the large conservation groups in this country. However, the tidal stream can also be harnessed by underwater turbines attached to the sea-bed which have far less of an environmental impact but which could nonetheless contribute significant amounts of electricity.

- **Small-scale hydropower** describes small hydropower schemes of below 5 MW the majority of which are small run-of-river schemes that do not involve damming. This power source will only be able to contribute a small amount of power with very local applications. An estimation of the total available resource (exploitation of every suitable site) suggests that approximately one fiftieth of the current electricity demand could be met by small-scale hydropower.

- **Geothermal energy** – there are only a certain number of potential geothermal sites around the country and these are unlikely to be able to produce large amounts of energy. Nevertheless, geothermal energy could provide a useful contribution to the local energy mix of those areas that are able to exploit it.

- Therefore a review of the overall **resource capacity of the renewables** suggests that there is no reason to believe that renewables are totally incapable of meeting the UK's *electricity* demand. This is clearly the case considering that offshore wind by itself could supply over three times the current consumption. This is not to say that there will not be technical challenges in ensuring that electricity will

be supplied when and where it is needed. This would be a particular challenge should the majority of electricity be produced by intermittent wind power. However, meeting all of the UK's *energy* demand through renewable power alone would be even more challenging as overall energy demand is substantially larger than electricity demand. This also raises the extra complication of how to convert renewably produced electricity into the heat and motive energy that the economy demands.

3.5.3 Characteristics of a Renewables System

- **A More Decentralised Electricity System**

As already outlined, renewable energy sources constitute a far less concentrated form of energy than the fossil fuels or nuclear power. Therefore, unlike nuclear power, renewables are not well suited to the centralised electricity system of large isolated generated units – perhaps with the exception of offshore wind farms. This means that a greater contribution from renewables is likely to involve the development of a more decentralised electricity system with high numbers of small-scale generating units plugged into the distribution network all over the country. At the moment renewables generators are finding it difficult and costly (due to institutional barriers) to plug into the network in this way, and the issue of "embedded generation" is already requiring the electricity industry to think about the system needs of renewable energy. The electricity system could become so decentralised that even individual householders could not only buy but also sell electricity to the grid at times when they are not in need of the electricity being produced by their PV cells and micro wind turbines. However, this increased contribution from renewables would present a substantial technical challenge for the national grid which presently depends upon the large proportion of constant, and controllable, electrical output from the fossil fuel and nuclear power stations in order to remain stable.

- **Heat and Motive Power**

Other than biomass, geothermal and solar thermal power, the renewables can only produce energy in the form of electricity. This may not seem to be too much of a problem considering that the demand for electricity is growing and it is the power

source of the electronic and telecom age. However, heat energy and motive energy are still the two biggest demand areas and are likely to remain so. Of course, electricity is one of the most flexible and useful forms of energy and it can be easily converted into other forms of energy such as heat or motion, although at a financial cost due to the energy losses. Nevertheless, this will still represent a technical challenge for renewables, in the same way as it would for nuclear power if it were to be used for these energy applications.

- **Intermittent Supply**

Wind, solar and wave power also face the problem of intermittent supply - electricity can only be produced when the wind is blowing, the sun is shining or the waves are crashed. Actually it is not as absolute as this in practice, particularly for solar and wave energy, but nevertheless the electricity output fluctuates with the weather conditions. If wind and solar are to play a significant role in a renewables intensive scenario (as they must, considering wind is the UK's largest renewable resource and is the most price competitive) then we must develop a way of storing the electricity they produce or of converting the electricity to a form of energy that can be stored more easily. The present-day options for storing electricity are fairly limited. Batteries are the best known electricity storage technology, but they aren't suitable for storing large amounts of electricity. Other storage technologies are beginning to emerge, such as the Regenesys system which is a chemical energy storage system in the same way as conventional batteries but can "load" and "unload" up to 120 MWh of electrical energy in one second.

- **The Hydrogen Economy**

The "hydrogen economy" represents the most popular idea for dealing with these limitations. It would involve the use of hydrogen to convert the energy obtained from renewables into the variety of forms that society requires and to transport the energy to wherever it is needed. The hydrogen economy would be a symbiotic relationship between renewables and fuel cells, and would utilise hydrogen as the energy carrier (a role that is currently carried out by electricity, and the fossil fuels). The basic theory is that renewables would produce electricity that could be used, through the electrolysis of water, to produce hydrogen. This hydrogen could then be piped anywhere, or stored – in the same way as natural gas. The hydrogen would

then provide the fuel for fuel cells which produce electricity or heat with only water as the waste product. A hydrogen economy would not depend upon the electrical national grid, in the same way as our present electricity system, because transported hydrogen would take the role of transmitted electricity, and its energy content could be converted to electricity by fuel cells in industry or in the home. Hydrogen would also take the role of transported oil and gas and could be used in fuel cell vehicles and in fuel cells in the home to provide heat. Homes could in theory provide much of their own energy needs through PV cladding and small wind turbines, and putting the fuel cells into "reverse" so that they could produce hydrogen for storage at times when energy isn't required.

Clearly, this vision of a renewables-hydrogen system represents quite a departure from our present energy systems. For this reason some people might consider it requires quite a leap of faith, and they may be uneasy with its novelty and its somewhat sketchy nature. The response from advocates of this vision is that we've got a long time to bring it about – fifty years or more – and it's a definite possibility, and so there's no reason to dismiss it now just because everything about the system hasn't been clearly and precisely outlined. Afterall, it would have been impossible to have clearly presented a model fifty years ago that perfectly predicted every aspect of our present energy systems.

3.5.4 Renewables – The Issues to be Resolved

- **The technical issues:**
  - The overall resource capacity of renewables
  - The intermittency of supply
  - Energy storage
  - Energy transport
  - The development of a new energy system

As is outlined above, renewables are profoundly different to fossil fuels and a renewables-based energy system would be very different from the present one. Essentially, in the progression towards a renewables economy we are entering an

unknown domain – industrial society has always been powered by fossil fuels and in this context renewable energy sources are very new. Although, a recent study by Greenpeace has calculated that offshore wind in UK territorial waters contains enough energy to meet our current electricity demand three times over, the actual job of harvesting this intermittent energy and delivering it to those who need it, when they need it, represents a significant challenge. I've already outlined a theoretical way of enabling renewables to satisfy the many differing energy demands that we have – the hydrogen economy. However, as I also pointed out, there are many people who are rather nervous about placing their entire faith in an as yet untested means of powering our economy. However, in the development of a vision of sustainable energy this leaves us with somewhat of a conundrum. Do we shy away from a vision of a renewable-based future because we lack perfect knowledge and are too nervous to risk backing something new and unknown? Or is this the sensible approach considering the importance of energy in powering our economy and enabling our modern way of life? (see section 5.4 below).

- **The economic issues:**
  - The cost of energy in a renewables-based energy system
  - The impact upon the economy – of both the transition and the final state

The potential economic impacts of an alternative energy system are discussed in section 5.4 below. As with any new technology, the cost of electricity from the renewables – other than some onshore wind – is currently higher than the well established fossil fuel generated electricity. However, it is likely that this price will fall with time. Nevertheless, we do not know how much the price will fall and therefore what the energy costs for our economy will be.

- **The environmental issues:**
- The impact upon the landscape of renewables infrastructure
- The specific impacts of the different renewable technologies

The environmental impacts of renewables are very different to those of fossil fuels and nuclear. Because of the diffuse nature of the renewable energy sources,

capturing large quantities of energy will require a huge infrastructure of renewables technologies. Therefore, a renewable-based energy system is likely to be far more visible than our current system. In addition to this each renewable energy technology has its own specific impact. For example, the manufacture and disposal of photovoltaic cells requires the handling of some toxic materials, and growing energy crops may bring the general environmental problems associated with modern agriculture.

3.6 A More Energy Efficient Economy?

Improvements in the efficiency of our energy use will be an essential component of sustainable energy and would complement both a nuclear and a renewable energy system. This is because the production of energy from all energy sources results in some kind of environmental impact and so reducing the energy intensity of our economy reduces the overall impact.

However, energy efficiency improvements have a particularly important role to play in a renewables-based energy system. As I've already outlined, a key concern for many people is that renewables might not be able to supply all of our energy needs, or at least be able to ensure quality of supply. This is of particular significance under conditions of increasing energy demand. The renewable resource is fixed and can not easily be increased to meet increasing demand in the same way as more and more fuel can be burnt or more and more uranium mined. Most renewables advocates would agree that a renewables-based future is in part dependent upon a more energy efficient economy which keeps energy demand constant if not actually decreasing.

So, if a renewables based energy future is partly dependent upon energy efficiency improvements, what improvements are actually possible? There is much disagreement over whether substantial efficiency gains are possible and over whether a super efficient economy could ever be realised. However, once again, a review of the technologies already available illustrates that huge efficiency gains are most definitely possible throughout the economy in industry, business and households. And if there were to be a focus on reducing the energy flows throughout our economy and the innovation of the market place was to be directed towards this end, then further substantial gains would be possible. This does not involve a denial

of the laws of thermodynamics but a recognition of the fact that our current way of doing things is highly resource and energy inefficient. There is no reason not to believe that energy demand could be reduced into the future whilst also accommodating many decades of economic growth.

4 CONCEPTUAL APPROACHES TO SUSTAINABLE ENERGY

4.1 The Historic Approach to Energy Policy

In the UK the historical significance of fossil fuels to the economy and society is immense, initially centred on coal but more recently moving into North Sea oil and gas. Energy is such a fundamentally important input to the economy that if supply is jeopardised, or fails to match demand, then there could be serious detrimental effects upon the economy. In recognition of this, the historical response of energy planners has been to focus energy policy almost entirely on issues of energy supply. This approach has been particularly pronounced for the electricity industry. Until privatisation in the late 1980s, the electricity industry was managed by the Central Electricity Generating Board whose principle objective was to ensure that there was sufficient supply which could cope with the most extreme peak load.

This over-emphasis on energy supply was at its most extreme during the euphoria surrounding nuclear power in the 1950s and the expectations that it would produce electricity too cheap to meter. Most industrialised countries around the world poured huge amounts of money into nuclear research – clearly this was in part due to the initial duel process of power generation and nuclear weapons manufacture - but is also an illustration of the great hopes that were placed on nuclear power to solve the energy supply problem. This preoccupation with large-scale supply, without giving much consideration to how energy demand might be managed, has also put renewable energy sources at a disadvantage because the planners perceive the answer to lie in large-scale intensive energy sources rather than more diffuse smaller-scale energy sources such as those typified by renewables.

The OPEC oil price shock was the first event in the post war era to properly focus attention on energy efficiency. However, this attention was not sustained and it has been the environmental agenda which has lead to the serious consideration of energy efficiency and renewables as potential players in ensuring energy security. The UK Government's commitment to sustainable development, and the acceptance that profligate and increasing consumption of resources without thought to the environmental consequences will not be sustainable in the long-term, has lead to an acceptance that a planning focus purely based on energy supply is unacceptable.

However, since privatisation of the utilities, the over-riding focus on supply has been replaced by a new policy goal - that of reducing the cost of electricity and heating fuels for the consumer.

The priority for energy planning today needs to be one of directing a transition to a sustainable energy system. Therefore, it requires the consideration of the many issues outlined in this paper. The challenge for energy policy will be to ensure that every effort is made to improve the efficiency of energy use and to encourage the development of non-fossil fuel based technologies, whilst also ensuring that the economy does not suffer (such as from unacceptably high prices). This makes the job of "energy planning" far more complicated and the assessment of all these varied criteria will require an entirely new process. For example, in assessing future energy demand, in say 2030, we now need to assess what energy efficiency improvements are technically and institutionally possible, and then superimpose this on the analysis of economic growth and economic change. These changes in the energy planning process represent a step-change for those involved in energy policy and it might take a while for decision-makers in industry and government to catch up.

4.2 Scale of Approach

It is possible to assess the impacts of energy technologies at two levels; at a micro, individual infrastructure level or a macro, overall energy system level. An approach at the overall system level allows the evaluation of the resource efficiency of the energy system in terms of how efficiently and successfully it delivers the services it is there to provide, for example in keeping us warm, or keeping our lights on. Traditionally, our energy systems have not been analysed in this way which has lead to an over-emphasis on the supply side issues. An assessment of the environmental impacts of different energy technologies may deliver very different results depending upon the scale at which the assessment is carried out. For example, we may consider an individual wind turbine to have a very small impact, and as it leads to no air or water pollution there is no obvious problem of combined impact in the same way as there is for fossil fuel combustion. However, if we intend to substantially increase wind power's contribution to our energy system then we may require very large numbers of turbines so that they are highly visible structures in

our landscape. This changes the nature of the assessment of the environmental impact – the question now concerns the very identity and appearance of the UK.

Approaching the issue at the system level also changes the technical and economic analysis of the issue. For example, many people undertake an assessment of renewables in terms of their ability to fit into the current electricity system, and cite the often high costs of the electricity they produce without paying attention to the unsuitability of the current system, in terms of its technical and institutional structure, to the renewable energy technologies. The assessment needs to go wider and to include the possibility of new models of energy provision. Renewables can be sited at individual houses to produce electricity that can be used when needed and sold to the grid when its not needed. However, a preoccupation with the large scale isolated generation units of the present electricity system without the consideration of doing things differently can lead to a dismissal of many alternative options. I think that the only way to obtain a full picture of all the potential technical options and of their sustainability (environmental and economic implications) is to approach the analysis at the system level as it enables a more imaginative consideration of the issues.

4.3 Energy for Sustainable Development – An Alternative Approach

4.3.1 Energy Systems for a More Sustainable Economy

By definition the main reason for seeking to achieve sustainable energy is so as to contribute to the larger goal of sustainable development. However, most people do not approach the analysis of sustainable energy in line with this. Instead they consider the challenge of sustainable energy to be one of finding a way of supplying the energy we need for our current economic activities without contributing to climate change or the depletion of fossil fuels. In this context the usual approach is to start with the various energy technologies and then evaluate their present day economic implications. However, if sustainable development requires us to fundamentally change the way we do things then our present day economic system will need to change. And, if our economy is going to change then our energy needs are going to change as well.

Therefore, an alternative approach to the analysis, is to define a sustainable energy system not in terms of its ability to supply copious amounts of energy with minimal environmental impact, but in terms of its contribution to (or place within) a truly sustainable economy.

This approach requires the development of a model of a sustainable economy, and the principles that must be met by an energy system if it is to contribute to sustainable development. However, this is a difficult job to perform because there are a number of different models of sustainable development, and there are many arguments over what constitutes a sustainable economy.

4.3.2 A Model of A Sustainable Economy

The consensus over sustainable development is not found in the vision of what constitutes a sustainable economy, but in the agreement that our current way of doing things is unsustainable. There is general agreement that we need to change our path of development so that it meets some broadly defined criteria but there is no agreement over exactly what a sustainable economy would look like in practical terms. Thus, an "energy for sustainable development" approach draws us into the debate over what constitutes a sustainable economy and what is our end goal sustainable society.

Can we find our desired model of a sustainable economy within the UK Government's Sustainable Development Strategy, "A Better Quality of Life"? Unfortunately, although this document outlines four general goals for sustainable development, and contains a number of objectives under each of these goals, it does not contain a blue-print for a sustainable economy. It is not a vision of a sustainable society but more of a "direction-planner" for unsustainable practices or trends that need to be changed or reversed. The ultimate question concerning sustainable development – i.e. can a continually growing economy ever be environmentally sustainable – is extremely difficult to answer, and its implications either way are profound. However, the UK Government has decided that a commitment to economic growth will be a component of its sustainable development strategy and that for the time being it will not seek to confront this issue.

4.3.3 The Super Efficient Economy

However, key objectives of the UK sustainable development strategy include more efficient use of resources in delivering the services that we demand and reductions in waste generation. If our economy is to continue growing whilst at the same time reducing its pressure on the environment (in terms of resource consumption and waste generation) then clearly we need to fundamentally increase the resource efficiency of our economy. In this way each unit of GDP can be produced with a smaller impact upon the environment by using less energy, less raw material, less water, less fertiliser, less pesticide, less land and so on. Providing the services that we require in a way that reduces the environmental inputs to our economy (i.e. improving resource efficiency) will not simply involve improving the eco-efficiency of manufacturing activity but will involve a far more radical change throughout our economy that focuses on providing services with minimal impact.

There are a number of authors developing our understanding of this theory of a sustainable economy, and a recent book, "Natural Capitalism" by Hawken et al, sets out the best blueprint yet for transforming our economy into one that best meets the principle of lessening environmental impact per unit of GDP. This is a model of sustainable development that seeks to maintain the services that are provided by our present unsustainable economy whilst also allowing for continued economic growth.

4.3.4 Weak or Strong Sustainability

Generally we might paint three alternative economic strategies for seeking to avoid environmental limits to our economic activity. The first I have just outlined. The second is to stabilise the economy, halt economic growth, reduce the industrial component and create a far simpler economy based on local production of goods and services. The third strategy is to continue along our current path of development and to increase the scale of energy production (from a non-fossil fuel source) so that we can sustain the voracious energy appetite of our growing economy – we might also hope to use yet more energy for the additional job of replacing all the lost services of our degraded environment. Clearly, these are somewhat superficial alternative models of a future economy that do not fully consider issues such as sustained natural capital. Nevertheless, I think they represent three general categories about how we may visualise future sustainable economies, and it is probably possible to

consider which could amount to "weak" or "strong" models of sustainability. I think the first model of a super efficient economy is the only option for strong sustainability in an industrialised world, and the modern way of life as we know it.

5 SUSTAINABLE ENERGY – ISSUES FOR CONSIDERATION

5.1 The Challenge of Predicting the Future

It is extremely difficult to predict how technologies and economic conditions will change in the future. Predicting future variables requires educated guess-work that involves extrapolating current trends whilst at the same time being alert to new developments which represent a complete change from the past. Therefore, an inherent part of assessing the future is the challenge of managing unknowns and uncertainties. There are tools for approaching future assessments and managing these uncertainties. The development of scenarios allows for a number of possible options to be explored - with the recognition that each scenario may be just as likely to occur.

As outlined above, energy planning has a particularly active history. However, more often than not, attempts at estimating future energy or electricity demand have been very wide of the mark, even over a period of just a few years. Long-term predictions of energy demand are extremely difficult to carry out, and any figures need to be accompanied by very wide error margins. This represents quite a challenge in the development of a vision of sustainable energy. We will need to have at least some kind of an idea of future energy demand if we are to evaluate which are the most suitable energy technologies. We also need to be able to assess how all energy technologies, on both the demand and supply sides, will change over time.

It is fair to say that most of the assessments of future energy demand and renewable energy developments that have been undertaken have tended to concentrate on extrapolating past trends. However, energy consumption in the past developed in a policy climate that focused on energy supply, and the renewables technologies were "developing" under conditions of very low R&D compared to the other energy supply technologies. Thus, extrapolating past trends to paint a picture of our future energy systems and using the past to assess how energy efficiency or renewables are likely to develop in the next twenty years may be a totally unsuitable approach. Energy policy in the past neglected these aspects of our energy systems and therefore it is unsurprising that they have only developed to play a small role in our present day energy systems. Thus, predicting the impact that sustainable development might

have on our energy systems is extremely difficult but it requires an open mind about the changes that are possible. Dealing with unknowns is a substantial challenge, and yet it is something that must be faced if we are to develop a vision of a desirable, but nevertheless realistic, energy future.

5.2 Assessing Technological Development

An assessment of what our future energy systems might look like is largely an exercise in technology assessment. This is because the way we produce and use energy is dependent upon various technologies, and our energy systems of the future will be based upon improved versions of these technologies and entirely new technologies. For example, in order to evaluate the potential of the various renewable energy sources we need to assess the current state of play of the renewable energy technologies and how they are likely to develop in the near, and the more distant, future. In the same way we need to assess the potential for energy efficiency improvements in our energy systems, and the potential for solving the nuclear waste issue. These are many of the issues that need to be looked at in a consideration of sustainable energy, and a sensible judgement is needed in order to come to an opinion on what is likely and what is not likely.

However, how are we to know how a particular technology will develop over time or when a particular technology is likely to reach maturity? Different people have different opinions concerning the potential of these different technologies and there is a great deal of argument over what is and what is not technically possible. However, the research and development stage is only one part of the process of bringing a new technology to the market place. Therefore an analysis of the deployment of new energy technologies needs to go well beyond the technical issues to include the economic, institutional and social barriers to the market place.

Although the claims and counter-claims of different interest groups may cause some degree of confusion there is, in fact, a good understanding of the current state of play of the various technologies due to research work carried out by a number of institutions, such as the DTI's Energy Technology Support Unit (ETSU). ETSU have undertaken an assessment of the resource capacity of the different renewable energy sources, and they have listed the different renewable energy sources in terms

of their ability to contribute to the UK's electricity generation in the short-term, medium-term and long-term. Therefore, there exists a sound impartial assessment of the current standing of the renewable technologies and of their likely development over the next twenty years or so.

5.3 Environmental Assessment

The wide range of criteria that a sustainable energy system would need to satisfy are listed in Paper 1. These include requirements such as security of energy supply and the financial cost of the energy in addition to the environmental impacts. Generally, these issues could be listed under the headings of environment, economy and society. The environmental consequences of conventional energy systems have already been outlined in Paper 1, and the impacts of climate change and air pollution are already well known. Although continuing research improves understanding of these impacts, it is already generally accepted that the large scale use of fossil fuels is unsustainable, and for this reason our current energy systems are unsustainable. There are some highly polarised views on the sustainability or otherwise of nuclear power. In section 3.5.4 above I listed some of the potential environmental impacts that may be associated with the exploitation of renewable energy sources.

In an environmental assessment of renewable energy technologies and nuclear power, or of alternative energy systems comprising different combinations of these two main energy sources, we are interested in what impacts can be accommodated in a sustainable world, and we are interested in a hierarchy of the environmental impacts. There are a number of approaches that could be adopted in an assessment of these environmental impacts. At first primary research is needed to highlight the impacts, and then on-going research can illuminate each of these impacts in more detail. However, in order to assess the unsustainability of these impacts we need to consider environmental limits, which will include issues such as irreversibility of impact, resource depletion or the ability of the environment to assimilate wastes or pollution. Unfortunately, assessing whether or not a particular impact breaches an environmental limit is not a simple or controversial-free exercise. One methodology for approaching such an analysis is The Natural Step, (registered with Forum for the Future) which is a science-based set of sustainability principles against which to evaluate the sustainability of an activity.

One way of avoiding difficult sustainability questions, is to concentrate instead on quantifying and comparing the impacts of different energy technologies or systems. However, each of the methodological approaches that seeks to do this, comes across the difficulty of how to weight and compare the different types of environmental impact. Each technique has its critics because the comparison of environmental impacts has a large subjective element. Who is to say whether a water pollution impact is better or worse than an air pollution impact? It is also extremely difficult to compare and contrast impacts that are profoundly different, such as nuclear waste and the visual impact of wind farms. Therefore, it often comes down to individuals' values and tastes when determining which is better or worse.

A recent large-scale study that sought to quantify and compare the impacts from the different energy sources was the "Externalities of Energy Production" study (ExternE). This used environmental economics valuation techniques to put monetary values on all the different impacts. However, a consideration of this study raises many points for debate. Although this study seeks to undertake an entirely objective approach to the analysis it nevertheless fails to remove the subjective elements of the debate. It is unsatisfactory in the way it deals with uncertainties, such as climate change impacts by assigning a monetary figure to the impacts even though we can only guess at what they might be. The monetary values obtained from each of the valuation techniques can also be queried, regardless of whether they use a surrogate market such as the effects of noise pollution on house prices, or more general questionnaires enquiring about willingness to pay to avoid specific environmental impacts. Therefore it still comes down to politics when deciding between the options.

5.4 Economic Impact

5.4.1 Renewables and the Industrial Economy

There are three scales at which an alternative energy system could have an economic impact. First, at the macro-scale there is the concern that a substantially changed energy system might not be able to sustain our economy in the way that we know it. The industrialised economy was founded on fossil fuels and energy is the

fundamental input to the modern economy. Therefore, many people are nervous about changing to a radically different energy system. Can a renewables energy system satisfy the energy demand of our economy, particularly since economic growth over the next 50 years is likely to increase demand? These questions lead us into the debate concerning what constitutes a sustainable economy (which is considered in section 4.3) and whether economic growth is sustainable. It is sensible to be wary of change that might destabilise our economy, but at the same time our commitment to sustainable development recognises the fact that we must change the way we do things – and unfortunately we'll never have perfect information about how exactly our economy will respond.

5.4.2 Fossil Fuel Dependent Industries

A second tier of concern relates to the impact of an energy transition upon the fossil fuel industry, and its many satellite industries, which constitute a fair chunk of the economy in their own right. For those who work in these sectors, the decline of fossil fuels will definitely be seen as an economic cost because their skills will become redundant. However, in the economy as a whole the development of a renewables industry (or enlarged nuclear industry) coupled with a bigger energy efficiency industry, could counteract the job loses in the fossil fuel sector, and may even produce more. Therefore in the long-term there should not be an economic cost (at least as long as the UK can retain a similar standing in the replacement industries) but there is a structural change in the economy. Sustainable development will confront this particular issue in many sectors across the economy because it requires changes in the way we do things – and with any change there are losers as well as winners. At the beginning of any transition the losers (in this case, the fossil fuel industry) are likely to outnumber the entrepreneurs (those in the energy efficiency and renewables industries) and as a result they have more lobbying power and form a barrier to the process of change. However, if a transition is gradual and well managed then the implications for the economy and society should, in theory, be small.

5.4.3 Competitiveness in a Competitive World

At another scale there is concern about the impact of higher energy prices for individual industries. Although there is no agreement over how the price of energy

would change under a more sustainable energy system, it is likely that energy would become more expensive under a nuclear or a renewables future (a higher price would also highlight the higher value attached to energy in a more sustainable society). If the UK undertakes changes to its energy markets unilaterally then the higher energy prices may put its energy-intensive industry at a disadvantage to similar industry in other countries. Therefore any increase in price is seen as threatening the competitiveness of certain industrial sectors and therefore is an economic impact. A reaction against this has already been witnessed after the announcement of the Climate Change Levy.

However, if the price increase were to become harmonised across the EU then it would be less of a problem. This shows the importance of the EU and the harmonisation of market conditions in Europe, and the importance of international agreements and cooperation. However, operating in a global market-place, the UK and all other countries will have to face many similar issues when re-structuring their economies along more sustainable lines. It is something that the world community will have to address as it progresses towards sustainable development. For this reason the potential impact of higher energy prices should only be considered as a short-term teething problem and should not concern a long-term vision of sustainable energy. However, although we may also be concerned that higher energy costs will cause general problems for the economy at large, a reduced consumption of energy through improved energy efficiency could counteract these price increases.

5.5 Higher Energy Costs Under An Alternative Energy System?

Fossil fuels produce cheaper electricity than either nuclear or renewables, although if a new coal power station were to be built today its electricity would be more expensive than that from wind. Many people are concerned that a renewables intensive energy system would supply energy at a far higher price than fossil fuels and for that reason would impact upon economic activity, and particularly energy intensive activities.

However, it is not just the energy conversion efficiency of the technology itself that determines the cost of the energy it produces. There are a huge number of variables that influence cost, and the arguments over the future cost of renewably produced

energy and the future cost of energy efficient technologies are just as rampant as those over the potentials of the technologies themselves. There are a significant number of institutional barriers that increase the price of renewable energy. . For example, the current electricity system isn't well designed for the small-scale decentralised input from renewables, and the small-scale generators are charged relatively large sums in network connection costs. In the long-run the system should develop the capacity to better accept embedded generation thereby reducing the cost of renewably produced electricity. There are also problems in the investment market. The cost of renewable energy can fall by a large amount once economies of scale are realised, and yet it is often difficult to attract large-scale investment for a new and unproven technology.

The initial implementation of new technologies into the economy is always associated with higher prices until the technology becomes better established and the means of producing, installing and maintaining the new technology or system matures within the economy. This is particularly important for renewables because they don't represent a direct replacement for fossil fuel technologies in the economy – in that they are a less dense, more diffuse energy sources and therefore require a differently designed, more decentralised system in order to produce the same energy services. This might mean that the costs of renewables are likely to reduce substantially over time as they become better established and our energy systems change accordingly.

Of course, fossil fuels are at a lower price than they should be. The external environmental cost associated with their use is not represented in their price. As a result the price signal fails and so does the allocative efficiency of the market place. It is impossibly difficult to calculate the exact level of this externality, and therefore the exact size of the Pigovian tax that would be needed to internalise this environmental cost. It could be argued that the climate change levy represents an attempt to include the climate change costs within the price of energy used by industry. However, nobody would dare to claim that the size of the climate change levy perfectly reflects the climate change impacts of that fuel use because we don' know what the exact impacts of climate change will be. Ultimately, we therefore depend upon the political system to determine the mix of energy sources that we

desire, and use policy instruments – which may or may not include market correction taxes - to achieve that mix.

6 COMING TO AN OPINION ON SUSTAINABLE ENERGY

6.1 Sustainable Energy - Sources Of Disagreement

6.1.1 The Politics of Sustainable Energy

Arriving at a vision of sustainable energy will inevitably involve subjective value judgements. The decision can not be entirely based upon objective scientific information. Although there are substantial opportunities for improving the knowledge base upon which to base decision-making about the alternative energy options there will always be unknowns and uncertainties. We will need to use judgement in determining how we deal with these uncertainties and also in choosing between different environmental impacts and the desirability of different economic situations associated with different energy systems. It is true that many debates about future energy systems need to be better informed and at present have too large a subjective component. However, it is not possible to remove this element altogether and this needs to be acknowledged at the outset so as to avoid the mistake of believing that continued research will resolve all the information gaps and unknowns.

6.1.2 The Objective and Subjective Elements in the Sustainable Energy Debate

There is a lot of confusion and disagreement within the debate over future energy systems. To help illuminate where the disagreements between different parties lie, it is useful to try and separate out the subjective elements from the objective elements in the energy debate. However, it is not easy to establish a decisive dividing line, and many of the aspects that could be classed as objective do, in fact, have a subjective component. However, it is also important to note that many of the disputes arise from ill-informed debate, and this can be resolved by obtaining research results from a number of institutions.

The subjective elements within the debate arise from three main sources:

- **Information gaps in the knowledge base that strategic research can fill** - such as collecting data, researching case-studies or modelling the resource capacity or economic impact of different energy technologies. At the moment

these information gaps exist and need to be managed during decision-making but future R&D can resolve the issues.

- **Permanent unknowns and uncertainties in the knowledge base** - for example, the assessment of how renewable energy technologies will development in the next twenty years requires judgement concerning a number of unknowns, and the debate concerning whether economic growth is or isn't sustainable in the long-term may never be conclusively resolved through academic research (in fact, such is the profundity and complexity of this particular question that perhaps it should instead be listed below as an example of different values). These unknowns are impossible to resolve in the short-term and they will only be known for sure in practice when the time actually arrives.

- **Personal preferences and different values** – some people like wind farms whilst others consider them to be blots on the landscape, some people believe that obtaining energy from the wind and the sun is morally superior to burning fuels, or that smaller scale structures and systems are favourable to larger ones, or vice-versa. The value base of individuals is extremely important because it can influence their assessment of the facts and figures (those aspects which may be considered objective) and it will certainly shape their assessment of the unknown quantities, and their interpretation of the issues. In this way it influences the first two sources of subjectivity listed above. Sometimes individuals' preferences or values are so strong that they will unknowingly ignore certain facts and figures, or question some figures whilst welcoming other data with unquestioning, open arms.

Therefore, in the energy debate there are subjective aspects to the technical assessment of the different energy systems and their economic and environmental impacts, and subjective aspects to the decision-making process regarding which option is the best, or most sustainable.

6.1.3 Opinions and Preferences can Change

However, this is not to say that the subjective aspects of the debate can not be analysed and evaluated in much the same way as the objective aspects. Individuals'

preferences and values change, and the process of analysing the issues can, in many cases, lead to permanent changes in values along with changes in opinion. For example, an individual may consider wind farms to be unsightly and therefore lobby against their development. However, the individual may have come to this decision without first considering the wider aspects of energy production, and the impacts of the current energy system upon the environment. A full consideration of the energy options might lead them to change their mind and to decide that wind power is a suitable option afterall, and that the visual impact upon the landscape represents is a trade-off that must be endured. After changing their minds in this way, some individuals may find their values to change to an even greater degree so that they don't find wind farms to be quite so ugly after all. This illustrates that preferences, in addition to opinions, can change with time, and can change with a proper consideration of the issues.

6.1.4 Education and Public Opinion on Energy

The values held by an energy expert are extremely important in shaping his or her opinion. Values are even more important in the shaping of general public opinion because they have far less information. However, as I've mentioned above, preferences are determined by cultural and individual values, both of which can change with time. In order to make good decisions the public needs to be well educated about all the options and the implications of those options. This is a dynamic and evolving process, and over time the opinions and values of the public at large will also change. For these reasons I do not intend to explore the present attitude of the public to renewable energy technologies or review local reactions to wind farms precisely because these attitudes will change as the energy choices, and their associated economic and environmental implications, become better known and better communicated. This education process will in fact also need to occur (and indeed is currently occurring) for energy planners and policy makers, and as knowledge of the various options improves the opinions of the planners will also change.

6.2 The Most Important Criteria for the Development of a Vision

6.2.1 The Issues Relevant to a Vision of Sustainable Energy

The wide range of criteria that a sustainable energy system would need to satisfy are listed in Paper 1. These include requirements such as security of energy supply and the financial cost of the energy in addition to the environmental impacts. However, it will be simpler to develop a long-term vision of sustainable energy if we prioritise the issues that need to be considered. Clearly, a vision isn't concerned with all the finer details of energy policy or with what constitutes the best policy instruments for increasing the share of renewables or the uptake of energy efficiency measures. In the same way the initial development of a vision need not be concerned with how it will be realised, and doesn't require a step by step guide outlining how it can be achieved. A vision is a long-term desirable, but nevertheless practical, goal. A vision which depends upon a technological break-through (in terms of something which is possible in theory but has yet to be proven in practice) is not a practical vision. However, it is perfectly acceptable to base a vision on expectations of the development and improvement in current technologies in line with the way those technologies have already developed over time.

For a long-term vision the important criteria to consider are:

- **The current standing of energy technologies, how they may develop over time and their ability to provide the services that we require;**
- **The impact that the deployment of these technologies might have upon the economy;**
- **The environmental impact associated with the deployment of these technologies, and;**
- **The energy needs of our society.**

6.2.2 The Prioritisation of Environmental and Economic Concerns

This is not to say that the social aspects of different energy systems aren't important. Of course our energy systems must be able to keep us warm, light our homes and

generally power our economy so that the needs of society are satisfied. However, these are economic issues rather than social issues. When considering a vision of sustainable energy the focus must be on the economic and environmental issues. Although economic activity is driven by culturally shaped individual actions, it is the economic activity itself that leads to environmental impacts. Therefore, an assessment of sustainable energy needs to focus on what are the requirements for a sustainable economy – i.e. how can we produce and use energy in a way that does not lead to long term environmental damage. This in turn will force society to decide exactly what services it does want, and which of the options for delivering these services, and their subsequent environmental and economic impacts, it likes best.

Domestic fuel poverty is clearly an extremely serious issue. However, fuel poverty is the result of inequality in our society and is not linked to the technical inability or otherwise of gas or electric heating systems. The consequence of fuel poverty is thermal discomfort and if those suffering from the problem could afford to do something about it then they could improve the situation either by better insulating their homes or burning more fuel or a combination of both.

6.2.3 The Inclusion of the Key Issues

Nevertheless, it is clear that there are many issues contained within each of the four general criteria above, including some which others might chose to describe as social.

The first, second and fourth criteria are linked in many ways. I use the term economy in the widest sense (as already discussed), and clearly the economy is not static because it is evolving and growing all the time. For this reason a consideration of the future energy needs of society (and the economy) requires an assessment of current energy use and how this is likely to increase or decrease in future years, which in turns requires an assessment of the potential for energy efficiency improvements throughout the economy. This is an economic issue because energy use is a fundamental aspect of the economy, and therefore changing the way we use energy (improvements in energy efficiency etc) requires changing practices in the economy.

I have not listed security of energy supply as a separate issue because all but one of the factors that determine security of supply are present above. The dependence upon other countries for fuel supplies, and therefore the threat of political or military instability affecting energy supply, is most importantly an issue for fossil fuels (although it could also affect nuclear power as well). However, it is clearly not a concern for renewables which obviously use locally provided fuels (wind, sun etc). It is likely that dependence on a foreign fuel would only be a concern for a future UK sustainable energy scenario if we desire natural gas and/ or oil to play a significant role well beyond the reserves in the North Sea are exploited. This is not to say that there would necessarily be no international trade under a hydrogen economy scenario – in fact hydrogen "reserves" could be traded from areas benefiting from good supplies of wind or sun which could be used to manufacture hydrogen as an export commodity.

6.3 Conclusions

This paper has sought to cover the broad range of issues that are relevant to a consideration of sustainable energy. It has argued the need for a vision of sustainable energy to guide UK energy policy, and it has highlighted the particular aspects that need to be focused upon in the development of a vision. The paper has introduced some options for alternative energy systems and outlined the sustainability criteria against which these options need to be evaluated. It has also explored the concept of economic impact in the context of sustainability and has argued that the sustainable energy debate should be re-defined so that it places sustainable development at the heart of the analysis of what constitutes a sustainable energy system.

Subsequent papers in the series will explore in more detail a number of the issues covered in this paper, such as the analysis of sustainable energy for a sustainable economy and the resource capacity of renewable energy sources.

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APPENDIX 5 – A LIST OF KEY INTERNAL AND EXTERNAL INTERVIEWS AND MEETINGS (excludes correspondences and meetings with members of the Sustainable Development Unit, which occurred regularly)

14-1-00	Meeting with Ed Gallagher, Chief-Executive
21-1-00	Meeting with Jan Pentreath, Chief-Scientist (Director of Environmental Strategy)
24-1-00	Meeting with Colin Powlesland, Policy Advisor, Process Industry Regulation
8-2-00	Telephone interview with Ian Taylor, Energy and Climate Change Policy, Greenpeace
15-2-00	Meeting with Jimi Irwin, Head of National Centre for Risk Analysis and Options Appraisal
28-1-00	Meeting with Paul Leinster, Director of Environmental Protection
15-3-00	Hosted Renewable Energy Workshop in conjunction with The Natural Step
30-3-00	Meeting of the Agency Climate change Steering Group
5-4-00	Correspondence with Giles Phillips, Head of Water Resources
19-4-00	Meeting with Neil Davies, Jimi Irwin, Ronan Palmer & Kate Hinton to discuss the Agency's influencing of electricity generation

4-5-00	Meeting with the Countryside Agency to discuss the environmental capital approach to the assessment of renewable energy
10-7-00	Meeting with the Environment Agency Chairman
18-7-00	Correspondence with Tim Reeder, Climate change Steering Group representative for Thames Region
28-7-00	Energy workshop with the NCRAOA
10-8-00	Meeting of the Energy Review Panel
23-8-00	Meeting with John Holmes, Head of Research and Development
12-9-00	Energy meeting with John Murlis, Chief-Scientist and David Mead, Head of National and International Relations
27-9-00	Correspondence with Tim De Winton, Strategic Planning, South West Region
27-10-00	Planning the Agency's response to the Royal Commission on Environmental Pollution's energy report and the government's renewable energy consultation with Peter Douben
22-11-00	General Environmental Strategy Directorate meeting on Refocusing the Directorate's work on strategic issues, such as energy
27-11-00	Hydrogen economy meeting with the Centre for the Exploitation of Science and Technology

4-12-00	Meeting with the Institute of Energy and Sustainable Development, De Montfort University
16-1-01	Meeting with Andrew Stunell MP, Liberal Democrat Energy Spokesperson
25-1-01	Correspondence with Glyn Edwards, Regional Scientist for the North East
31-1-01	Attended the renewable energy stakeholder consultative event in Cumbria (regional Agency office played a main role)
7-2-01	Resources Board Advisory Group consideration of the Renewable Energy Position – attended meeting and discussion
25-4-01	Resources Board Advisory Group consideration of the sustainable energy vision
22-5-01	Meeting with Terry Coleman, Waste Strategy Manager
25-5-01	Meeting with Robin Chatterjee, Briefing Policy Manager
30-5-01	Participation in the Performance and Innovation Unit's (Cabinet Office) workshop on resource and energy productivity
14-6-01	Meeting with Michelle Doyle and Catherine Braun, Government and Parliamentary Relations Team
15-6-01	Correspondence with Kate Hinton, Public Affairs Manager
19-7-01	Participation in the Parliamentary Office of Science and Technology Electricity Networks workshop

24-7-01	Correspondence with Ted Cantle, Board Member
26-7-01	Meeting with Sara Parkin, Board Member
31-7-01	Organised Energy Workshop for key Agency staff
2-8-01	Meeting with the Chairman to discuss an Agency energy position
16-8-01	Meeting with the Energy Review Team in the Cabinet Office to discuss the energy vision and the energy review
17-8-01	Meeting with Helen McCallum, Director of Corporate Affairs to discuss Agency policy advocacy on sustainability issues

A Sample of the Questions and Issues Raised in the Interviews

Through raising the questions below I encouraged interviewees to consider the issues of my project work and raise their consciousness of the issues. Hence, they could not answer a number of the questions.

- Do you think that the Agency should develop an energy position?
- Do you think it would be useful for the Agency to develop a sustainable energy vision – to inform and develop a shared understanding of sustainable energy, both internally and in the UK as a whole?
- Do you think the Agency would be able to achieve consensus on an energy position?
- What role do you think the Agency should play in sustainable energy? What contribution do you think the Agency can make to sustainable energy policy and practice in the UK?

- Should the Agency adopt a policy advocacy role for energy?

- How else could the Agency make a significant impact on sustainable energy in the UK?

- Do you have a personal vision of sustainable energy? What do you believe to be the key issues and the greatest government policy failures? What do you consider to be the key sustainable energy solutions?

- Do you consider energy and climate change to be a depressing problem, or an exciting opportunity?

- How could the Agency be more conscious of energy efficiency (and greener energy supplies) in its own work?

- How could the Agency undertake an internal deliberation process to develop a shared energy position? What structures and processes would need to be put in place?

MEMBERS OF THE SUSTAINABLE DEVELOPMENT UNIT

- Chris Newton, Head of Sustainable Development
- Ronan Palmer, Chief Economist
- Richard Howell, Strategic Issues and Biodiversity Manager
- John Colvin, Social Policy Manager
- Henry Leveson-Gower, Economic Analyst
- Philip Douglas, Policy Development Officer
- Peter Brown, Policy Development Officer
- Ben Maxwell, Technical Officer
- Nina Smith, Administration Support

APPENDIX 6 – EVIDENCE OF PROJECT IMPACTS

- **CHAIRMAN MEMO ABOUT THE ENERGY VISION**
- **CHAIRMAN MEMO FOLLOWING OUR MEETING**
- **GUARDIAN ARTICLE THAT MENTIONS THE ENERGY VISION**

memo

ENVIRONMENT AGENCY

To	John Murlis	Our ref	SJH/RJB/Murlis0701.18
From	Sir John Harman	Your ref	
Ext. Number	8720	Date	18 July 2001

DAN ARCHARD'S SUSTAINABLE ENERGY VISION

1. A lot in it which the Agency could/should support. At the moment it is his work only, not an EA position; but I would like it to proceed, migrating to a formal adoption, which will probably require some changes. For instance, the italicised portion (the "Vision") includes several hostages to fortune. But you could conceivably divide the document so that the "Vision" is acknowledged as a piece of informed creative writing, while the commentary/analysis/mainoutcomes described in the Vision, become formally adopted.

2. The route for adoption should include Resources BAG. So, has Richard Macrory seen the document? If not, he should.

3. I'm looking (see my objectives) for a small number of topics on which I can organise EA seminars. This topic seems ideal. (Perhaps we can invent a new class of EA documents intermediate between "policy" and "reporting" which allow us to set a debate going and take an advocacy stance short of full commitment.) Depending on your advice CAG could be the vehicle for considering such use of the document.

4. Thank Dan for me!

SIR JOHN HARMAN
CHAIRMAN

cc. Chris Newton
Michelle Doyle
Catherine Braun
Barbara Young
Paul Leinster
Bob Leng

Chairman's Office
Environment Agency, Millbank Tower, 25th Floor, 21-24 Millbank, London SW1P 4XL
Telephone Number 0207.863.8720 Fax Number 0207.863.8722

memo

ENVIRONMENT AGENCY

To	John Murlis	Our ref	SJH/RJB/Murlis0800.17
From	Sir John Harman	Your ref	
Ext. Number	8720	Date	17 August 2000

I have to hand Richard Macrory's note to you concerning Energy Policy, and his contact with Michael Grubb. This has prompted me to drop you a line on Energy Policy which I have been meaning to do ever since the last Board Meeting, but never quite got round to it.

During my update session in the morning of that meeting, I asked Richard to bring the Board up-to-date on the RCEP report on climate change. After a short debate it was generally agreed that the Agency should seek to develop a range of informed positions on Energy Policy and in particular on its environmental impacts. I now note that this has not been recorded as an action point, and this memo is to ensure that you and Ed are aware of the request.

Over recent weeks I have had conversations with Dan Archard and Chris Newton which suggest to me that nobody is quite sure where the Agency wants to go on this matter. Can I therefore make it clear that I believe that the area of Energy Policy is an important opportunity for us to illustrate what the new Vision describes as a stronger influencing role.

I would therefore like to talk to you and Ed, if he wishes, together with any other staff that you think are appropriate, on exactly what form this activity could take within the Agency, what resources we need to put towards it, and whether we need to commission any R&D to underpin our revolving positions. On the whole, I think it should not be that difficult, and perhaps you already have it in hand.

I have also copied this note to Barbara Young for her information. Although she is not yet in post, I am starting to copy her in on "developmental" matters, for obvious reasons.

SIR JOHN HARMAN
CHAIRMAN

cc. Richard Macrory
David Viles
Ed Gallagher

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